Section 2

High-Consequence Livestock Pathogens

African Swine Fever

Pesti Porcine Africaine, Peste Porcina Africana, Maladie de Montgomery

Last Updated: Sept. 21, 2004

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Importance

African swine fever is a serious viral disease of pigs, endemic in Africa. Isolates vary in virulence from highly pathogenic strains that cause near 100% mortality to low–virulence isolates that can be difficult to diagnose. Disease outbreaks have occurred in numerous countries and the cost of eradication has been significant. During outbreaks in Malta and the Dominican Republic, the swine herds of these countries were completely depopulated.

Etiology

African swine fever results from infection by the African swine fever virus (ASFV). Formerly classified as a member of the Iridoviridae, this virus is currently the only member of a family called "Asfarviridae." The ASF virus is the only DNA virus that is transmitted by arthropods. The virulence of virus isolates varies.

Species affected

African swine fever affects domestic pigs and wild pigs, including the warthog, bush pig, and giant forest hog in Africa and the feral pig in the island of Sardinia, Italy. Symptomatic infections occur in domestic pigs and feral pigs; infections are generally asymptomatic in warthogs, bush pigs, and giant forest hogs.

Geographic distribution

African swine fever is endemic in most of sub–Saharan Africa; the highest incidence of disease is seen from the Equator to the northern Transvaal. This disease is also found in feral pigs in Sardinia, Italy.

Transmission

African swine fever can be transmitted by direct contact with infected animals, indirect contact on fomites, and by tick vectors. Transmission during direct contact is usually by oronasal spread. African swine fever virus can be found in all tissues and body fluids, but particularly high levels are found in the blood. Massive environmental contamination may result if blood is shed during necropsies or pig fights, or if a pig develops bloody diarrhea. The virus can also spread on fomites, including vehicles, feed, and equipment. There is evidence that some pigs may become carriers.

African swine fever often spreads to new areas when pigs are fed uncooked scraps that contain ASFV–infected pork. In one outbreak, pigs became infected after being fed the intestines of guinea fowl that had eaten infected ticks. The African swine fever virus is highly resistant to environmental conditions. It can survive for 15 weeks in chilled meat, a year and a half in blood stored at 4º C, 11 days in feces at room temperature, and at least a month in contaminated pig pens. The virus will also remain infectious for 150 days in boned meat stored at 39º F, 140 days in salted dried hams, and several years in frozen carcasses.

African swine fever is also spread through the bite of infected soft ticks *Ornithodoros spp*.ticks. In tick populations, transstadial, transovarial, and sexual transmission occur. In Africa, this disease is thought to cycle between newborn warthogs and the soft ticks that live in their burrows. Infected soft tick colonies can maintain the ASF virus for long periods of time, measured in years.

Incubation period

The incubation period is 5 to 15 days.

Clinical signs

African swine fever can be a peracute, acute, subacute, or chronic disease. More virulent isolates cause a high fever, moderate anorexia, leukopenia, recumbency, and skin reddening that is most apparent in white pigs. Some pigs develop cyanotic skin blotching on the ears, tail, lower legs, or hams. Diarrhea and abortions are sometimes seen, but most pigs infected with this virus remain in good condition. In infections with highly virulent isolates, progressive anorexia and depression develop and are usually followed by death within 7 to 10 days. The death rate is generally lower in ani-

mals infected with moderately virulent isolates, but may still be very high in very young animals.

Animals infected with isolates of low virulence may seroconvert without symptoms, abort, or develop chronic African swine fever. The symptoms of chronic disease are a low fever, which may recur, and sometimes pneumonia or painless swelling of the joints, particularly the carpal and tarsal joints. Reddened foci may appear on the skin and become raised and necrotic. In some cases, the only clinical signs may be emaciation and stunting. Chronic African swine fever can be fatal.

Post mortem lesions

The most consistent and characteristic lesions occur in the spleen and lymph nodes. In animals infected with highly virulent isolates, the spleen is usually very large, friable, and dark red to black. In pigs infected with moderately virulent isolates, the spleen is also enlarged, but not friable, and the color is closer to normal. The lymph nodes are often swollen and hemorrhagic and may look like blood clots; the nodes most often affected are the gastrohepatic, renal, and mesenteric lymph nodes. Edema may also be seen in other lymph nodes, and the tonsils are often swollen and reddened.

Less consistent clinical signs include hemorrhages, petechiae, and ecchymoses in other organs. Petechiae may be present on any organ, but most are located on the renal cortex, bladder, lungs, and heart. Ecchymoses and "paint–brush" hemorrhages are often found on the serosa of the stomach and intestines. Edema may be seen in the lungs and gall bladder, and the pleural, pericardial, and peritoneal cavities may contain excess fluid. In some pigs, dark red or purple areas may be found on the skin of the ears, feet, and tail. Aborted fetuses may be anasarcous, have a mottled liver, and contain petechiae in the placenta, skin, and myocardium.

In animals with chronic African swine fever, the most common post–mortem lesions are focal areas of skin necrosis, consolidated lobules in the lung, fibrinous pericarditis, generalized lymphadenopathy, and swollen joints.

Morbidity and Mortality

In domestic pigs, morbidity approaches 100% in herds that have not been previously exposed to the virus. Mortality varies with the virulence of the isolate, and can range from 0% to 100%. Low virulence isolates are more likely to be fatal in pigs with a concurrent disease, pregnant animals, and young animals. Mild or asymptomatic disease is usually seen in warthogs and bush pigs.

No treatment or vaccine exists for this disease.

Diagnosis

Clinical

African swine fever should be suspected in pigs with a fever, when the necropsy findings include a very large, friable, dark red to black spleen and greatly enlarged and hemorrhagic gastrohepatic and renal lymph nodes.

Differential diagnosis

The differential diagnosis includes hog cholera (classical swine fever), porcine dermatitis and nephropathy syndrome, erysipelas, salmonellosis, eperythrozoonosis, actinobacillosis, Glasser's disease (*Haemophilus parasuis* infection), Aujeszky's disease, thrombocytopenic purpura, warfarin poisoning, and heavy metal toxicity.

Laboratory tests

In areas where African swine fever is not endemic, this disease should be diagnosed by virus isolation and the detection of viral antigens. Blood and tissue samples from suspect pigs are inoculated into pig leukocyte or bone marrow cultures for virus isolation. African swine fever virus induces hemadsorption of pig erythrocytes to the surface of infected cells. The virus can also be detected with peripheral blood leukocytes from infected pigs in a hemadsorption "autorosette" test.

African swine fever virus antigens can be found in tissue smears or cryostat sections by the fluorescent antibody test (FAT). Nucleic acids can be detected by a polymerase chain reaction (PCR) assay. PCR is particularly useful in putrefied samples that cannot be used for virus isolation and antigen detection.

Serology is carried out simultaneously with virus isolation. Antibodies to ASFV persist for long periods of time after infection. Serology may also be used for diagnosis in endemic areas. Available serologic tests include the enzyme–linked immunosorbent assay (ELISA), immunoblotting, indirect fluorescent antibody (IFA), and counter immunoelectrophoresis (immunoelectro–osmophoresis) tests. The ELISA is prescribed for international trade.

Samples to collect

Before collecting or sending any samples from animals with a suspected foreign animal disease, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent the spread of the disease.

For virus isolation from live animals, blood should be collected into an anticoagulant and antibiotics should be added. At necropsy, samples of the spleen, lung, liver, kidney, and tonsils, as well as the submandibular, inguinal, and gastrohepatic lymph nodes should be collected aseptically. Samples of the bone marrow should be sent if significant postmortem changes are seen. ASFV is not

found in aborted fetuses; in cases of abortion, a blood sample should be collected from the dam. Samples for virus isolation should be transported cold on wet ice or frozen gel packs.

Samples of the same tissues, the brain, and any other grossly abnormal tissues should be submitted for histology. Serum and/ or tissue fluids should be submitted for serology

Recommended actions if African swine fever is suspected

Notification of authorities

African swine fever should be reported to state or federal authorities immediately upon diagnosis or suspicion of the disease. Federal: Area Veterinarians in Charge (AVICS) http://www.aphis.usda.gov/vs/area_offices.htm

State vets: http://www.aphis.usda.gov/vs/sregs/official.html

Quarantine and Disinfection

To prevent introduction of the African swine fever virus into areas free of the disease, all garbage fed to pigs should be cooked. Unprocessed meat must be heated to at least 70ºC for 30 minutes to inactivate the virus; 30 minutes at 60ºC is sufficient for serum and bodily fluids.

African swine fever is a contagious disease. Eradication is by slaughter of infected and in–contact animals, and disposal of carcasses, often by burying, rendering or burning. Strict quarantine must be imposed, and potential tick vectors should be controlled with acaricides. In cases of ASF outbreaks, there must be a detailed entomological investigation for the possibility of soft tick vectors and their role as long term carriers. In the outbreaks in the Americas, the Ornithodoros ticks never became chronically infected. But in Spain, Portugal and Africa, infected soft ticks can carry the ASFV for many years. Many common disinfectants are ineffective; care should be taken to use a disinfectant specifically approved for African swine fever. Sodium hypochlorite and some iodine and quaternary ammonium compounds are effective.

Public health

Humans are not susceptible to African swine fever virus.

For More Information

World Organization for Animal Health (OIE)

http://www.oie.int

OIE Manual of Standards

http://www.oie.int/eng/normes/mmanual/a_summry.htm

OIE International Animal Health Code

http://www.oie.int/eng/normes/mcode/A_summry.htm

USAHA Foreign Animal Diseases book

http://www.vet.uga.edu/vpp/gray_book/FAD/

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Classical Swine Fever

Hog Cholera, Peste du Porc, Colera Porcina, Virusschweinepest

Last Updated: Sept. 21, 2004

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Importance

Classical swine fever is a serious and highly contagious viral disease of pigs. Acute or chronic infections occur; both are usually fatal. In herds infected with less virulent isolates, the only symptom may be poor reproductive performance or a failure to thrive. A wide range of clinical signs and a similarity to other diseases can make classical swine fever challenging to diagnose.

Etiology

Classical swine fever results from infection by classical swine fever virus (CSFV), (genus Pestivirus, family Flaviviridae). This virus is also known as hog cholera virus. Only one serotype has been found. The CSF virus is very similar to the Bovine Virus Diarrhea (BVD) virus that affects cattle.

Species affected

Classical swine fever affects domestic and wild pigs.

Geographic distribution

Classical swine fever is found in East and Southeast Asia, the Indian subcontinent, China, East and Central Africa, and most of South and Central America. This disease has been eradicated from the United States, Canada, New Zealand, and Australia. Most of Western Europe is free of classical swine fever; however, foci of infection remain in Germany and some countries of Eastern Europe.

Transmission

Classical swine fever is highly contagious. Virus transmission is mainly oral; CSFV is often spread by feeding uncooked contaminated garbage. Animals can also be infected through the mucus membranes, conjunctiva, and skin abrasions. Aerosol spread is sometimes seen in confined spaces; however, the virus does not travel long distances in the air. Infected carrier sows may give birth to persistently infected pigs. Mechanical spread by fomites and insects occurs.

Infected pigs are the only reservoir of virus. Blood, secretions and excretions, and tissues contain infectious virus. CSFV is moderately fragile in the environment, but can remain infectious for months in refrigerated meat and years in frozen meat. It can survive in contaminated pens and on fomites for as long as two weeks.

Incubation period

Variable incubation periods have been published, ranging from 2 to 14 days.

Clinical signs

The clinical signs of classical swine fever vary with the strain of virus and susceptibility of the pigs. More virulent strains cause acute disease; less virulent strains can result in a high percentage of chronic, mild, or asymptomatic infections.

In acute classical swine fever, common clinical signs include a high fever, dullness, weakness, drowsiness, huddling, anorexia, an unsteady gait, conjunctivitis, and constipation followed by diarrhea. Several days after the first symptoms appear, the abdomen, inner thighs, and ears may develop a purple discoloration. Convulsions may be seen in the terminal stages. Pigs with acute classical swine fever often die within one to two weeks.

The symptoms of chronic disease include intermittent fever, anorexia, periods of constipation or diarrhea, stunted growth, and alopecia. Immunosuppression may lead to concurrent infections. The symptoms of chronic infections can wax and wane for weeks to months and may affect only a few animals in the herd. Chronic infections are almost always fatal.

Reproductive symptoms may also be seen. Virulent strains can cause abortions or the death of piglets soon after birth. Less virulent strains of CSFV may result in stillbirths or mummification. Some piglets are born with a congenital tremor or congenital malformations of the visceral organs and central nervous system. Other piglets are asymptomatic but persistently infected. These animals are persistently viremic and

become clinically ill after several months. They may have mild anorexia, depression, stunted growth, dermatitis, diarrhea, conjunctivitis, ataxia, or paresis, and may die. In some breeding herds infected by less virulent strains, poor reproductive performance is the only sign of disease.

Post mortem lesions

The lesions of classical swine fever are highly variable. In acute disease, the most common lesion is hemorrhage. The skin may be discolored purple and the lymph nodes may be swollen and hemorrhagic. Petechial or ecchymotic hemorrhages can often be seen on serosal and mucosal surfaces, particularly the kidney, urinary bladder, epicardium, larynx, trachea, intestines, subcutaneous tissues, and spleen. Straw–colored fluid may be found in the peritoneal and thoracic cavities and the pericardial sac. Necrotic foci are common in the tonsils. Splenic infarcts are occasionally seen. The lungs may be congested and hemorrhagic. In some acute cases, lesions may be absent or inconspicuous.

The lesions of chronic disease are less severe and may be complicated by secondary infections. In addition, necrotic or "button" ulcers may be found in the intestinal mucosa, epiglottis and larynx.

In congenitally infected piglets, common lesions include cerebellar hypoplasia, thymic atrophy, ascites, and deformities of the head and legs.

Morbidity and Mortality

Both morbidity and mortality are high in acute infections. The mortality rate in acute cases can reach 90%. Chronic infections are also fatal in most cases.

Vaccines may be available in some areas. Vaccines can protect animals from clinical disease, but do not prevent infections. Good vaccination programs can eventually eliminate the infection in herds.

Diagnosis

Clinical

Classical swine fever should be suspected in pigs with septicemia and a high fever, particularly if uncooked scraps have been fed, unusual biological products have been used, or new animals have been added to the herd. Differentiation from other diseases may be difficult without laboratory testing. In acute outbreaks, the chance of observing the characteristic necropsy lesions is better if four or five pigs are examined.

Differential diagnosis

The differential diagnosis includes African swine fever, porcine dermatitis and nephropathy syndrome, erysipelas, eperythrozoonosis, salmonellosis, actinobacillosis, Glasser's disease (*Haemophilus suis* infection), thrombocytopenia purpura, warfarin poisoning, Aujeszky's disease, heavy metal poisoning, and salt poisoning. Pigs congenitally infected with bovine virus diarrhea (BVD) virus may look very similar to pigs with classical swine fever.

Laboratory tests

Classical swine fever can be diagnosed by detecting the virus or its antigens in whole blood or tissue samples. Virus antigens are detected by direct immunofluorescence or enzyme–linked immunosorbent assays (ELISAs). CSFV is differentiated from other pestiviruses by immunofluorescence testing with monoclonal antibodies. The virus can also be isolated in several cell lines including PK–15 cells; it is identified by direct immunofluorescence or peroxidase staining. Reverse transcriptase polymerase chain reaction (RT–PCR) tests are available.

Serology is used for diagnosis and surveillance. The most commonly used tests are virus neutralization tests, including the fluorescent antibody virus neutralization (FAVN) test, the neutralizing peroxidase–linked assay (NPLA), and ELISAs. Antibodies usually develop during the third week after infection, but cannot be reliably detected until 30 days after infection. They persist for life. Antibodies against ruminant pestiviruses may be found in breeding animals; only tests that use monoclonal antibodies can differentiate between these viruses and CSFV.

Samples to collect

Before collecting or sending any samples from animals with a suspected foreign animal disease, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent the spread of the disease.

Samples should be taken from at least four pigs. In live pigs, whole blood is preferred but tonsil biopsies are sometimes useful. Serum samples should be taken from recovered animals or sows that have been in contact with suspected cases.

At necropsy, the tonsils should be submitted for virus isolation or antigen detection. Other organs to collect include the submandibular and mesenteric lymph nodes, spleen, kidneys, and the distal part of the ileum. Samples for antigen detection and virus isolation should be refrigerated but not frozen; they should be kept cold during shipment to the laboratory. A complete set of tissues, including the whole brain, should be submitted in 10% buffered formalin for histology.

Recommended actions if classical swine fever is suspected

Notification of authorities

Classical swine fever should be reported immediately upon diagnosis or suspicion of the disease.

Federal: Area Veterinarians in Charge (AVICS) http://www.aphis.usda.gov/vs/area_offices.htm

State vets: http://www.aphis.usda.gov/vs/sregs/official.html

Quarantine and Disinfection

CSFV is moderately fragile in the environment. This virus is sensitive to drying and ultraviolet light and is rapidly inactivated by a pH less than 3. Sodium hypochlorite and phenolic compounds are effective disinfectants. CSFV can survive for long periods in meat, but is destroyed by cooking.

During outbreaks, confirmed cases and contact animals may be slaughtered and aquarantine imposed. Vaccination may be used as a tool to assist in controlling an outbreak and eradicating the disease. In countries free of classical swine fever, periodic serologic sampling is necessary to monitor for the potential reintroduction of disease.

Public health

Classical swine fever does not affect humans.

For More Information

World Organization for Animal Health (OIE)

http://www.oie.int

OIE Manual of Standards

http://www.oie.int/eng/normes/mmanual/a_summry.htm

OIE International Animal Health Code

http://www.oie.int/eng/normes/mcode/A_summry.htm

USAHA Foreign Animal Diseases book

http://www.vet.uga.edu/vpp/gray_book/FAD/

Animal Health Australia. The National Animal Health Information System (NAHIS)

http://www.aahc.com.au/nahis/disease/dislist.asp>

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"Hog Cholera." Animal Health Australia. The National Animal Health Information System (NAHIS). 24 Oct 2001 <http://www.aahc.com.au/nahis/disease/dislist.asp>.

Foot and Mouth Disease (FMD)

Fiebre Aftosa

Last Updated: Mar. 10, 2004

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Importance

Foot-and-mouth disease (FMD) is highly contagious and can rapidly spread through a region if control and eradication practices are not put into place as soon as the disease is identified. Weight loss, poor growth, permanent hoof damage, and chronic mastitis are just some of the sequelae of infection. As a result, international trade embargoes could cause significant economic losses.

Etiology

The foot-and-mouth disease virus (FMDV) is in the family Picornaviridae, genus *Aphthovirus*. There are 7 immunologically distinct serotypes and over 60 subtypes. New subtypes occasionally develop spontaneously. The FMDV is inactivated at a pH below 6.5 or above 11. The virus can survive in milk and milk products when regular parteurization temperatures are used. However, it is inactivated when ultra high pasteurization procedures are used. Virus stability increases at lower temperatures. It can survive in frozen bone marrow or lymph glands. In organic material such as serum, the virus can survive drying. It can remain active for days to weeks on organic rich materials under moist and cool temperatures. It is inactivated on dry surfaces and by UV radiation (sun light)

Species affected

FMDV primarily affects cloven-hoofed domestic and wild animals, including cattle, pigs, sheep, goats, and water buffalo. Other susceptible species include hedgehogs, armadillos, nutrias, elephants, capybaras, rats, and mice.

Geographic distribution

Foot-and-mouth disease was found worldwide after World War II. The last U.S. outbreak was in 1929. Endemic areas are Asia, Africa, the Middle East, and parts of South America. Epidemics occurred in recent years in Taiwan, South Korea, Japan, Mongolia, Britain, France, and The Netherlands. North and Central America, Australia, and New Zealand have been free for many years.

Transmission

Transmission primarily occurs by respiratory aerosols and direct or indirect contact with infected animals. Aerosol transmission requires proper temperature and humidity. Aerosol spread has occurred from bulk milk trucks. After conditions of heavy aerosol inhalation, FMDV can survive for 24 hours in the human respiratory tract. Feeding of infected animal products such as meat, milk, bones, glands and cheese can also spread the disease. Contact with contaminated objects such as boots, hands or clothing can be a source of infection. Another source of infection is artificial insemination and contaminated biologicals and hormone preparations.

Sheep and goats are considered maintenance hosts. They can have very mild signs; therefore, diagnosis may be delayed allowing time for aerosol and contact spread and environmental contamination. In pigs, FMDV spreads rapidly due to thousands of times higher virus particle concentration in aerosols as compared with other species. They are considered amplifying hosts. Cattle are considered 'indicators' of this disease because they generally are the first species to show signs of infection. Their lesions are more severe and progress more rapidly.

Ruminants can carry the virus for long periods in their pharyngeal tissue. Recovered or vaccinated cattle exposed to diseased animals can be healthy carriers for 6-24 months. Sheep can be carriers for 4-6 months. Pigs are not carriers of FMDV. Some strains of the virus can affect one species more than others.

Incubation period

Animals in contact with clinically infected animals will generally develop signs of disease in 3-5 days. The virus can enter through damaged oral epithelium or the tonsils in pigs fed contaminated garbage. In this case signs can be seen in 1-3 days. Experimental exposure can elicit signs in 12-48 hours. Peak time of shedding of the virus and transmission usually occurs when vesicles rupture.

Foot and Mouth Disease (FMD)

Clinical signs

Foot-and-mouth disease is characterized by fever and vesicles (blisters), which progress to erosions in the mouth, nares, muzzle, feet, or teats. Typical clinical signs include depression, anorexia, excessive salivation, serous nasal discharge, decreased milk production, lameness, and reluctance to move. Abortion may occur in pregnant animals is due to high fever (FMD virus does not cross the placenta). Death in young animals is due to severe myocardial necrosis. In cattle, oral lesions are common with vesicles on the tongue, dental pad, gums, soft palate, nostrils, or muzzle. Hoof lesions are in the area of the coronary band and interdigital space. In pigs the hoof lesions are usually severe with vesicles on the coronary band, heel, and interdigital space. Vesicles can be seen on the snout. Oral lesions are not as common as in cattle and are usually less severe. Drooling in pigs is rare. Sheep and goats show very mild, if any, signs of fever, oral lesions, and lameness. Animals generally recover in about 2 weeks with very low mortality in adult animals. Secondary infections may lead to a longer recovery time.

Post mortem lesions

The diagnostic lesions of foot-and-mouth disease are single or multiple vesicles from 2mm to 10cm in size. Lesions may be seen in any stage of development from a small white area to a fluid filled blister, sometimes joining with adjacent lesions. The vesicles rupture, leaving a red eroded area, which is then covered with a gray fibrinous coating. This coating becomes yellow, brown, or green then is replaced by new epithelium with a line of demarcation that gradually fades. Occasionally the fluid may escape through the epidermis instead of forming a vesicle. These "dry" lesions appear necrotic instead of vesicular. "Dry" lesions are more common in the pig oral cavity. Lesions at the coronary band progress similarly: the skin and hoof separate and, as healing occurs, a line showing evidence of coronitis appears on the hoof. Pigs may actually lose the hoof in severe cases. "Tiger heart" lesions may also be seen; these lesions are characterized by a gray or yellow streaking in the myocardium caused by degeneration and necrosis. Vesicular lesions may also be seen on the rumen pillars.

Morbidity and Mortality

Morbidity can be 100% in a susceptible population. Mortality is generally less than 1%. In younger animals or with more severe strains mortality can increase.

Diagnosis

Clinical

Clinical signs of concurrent salivation and lameness with vesicular lesions should make foot-and-mouth disease a differential consideration. Fever is often the first sign, so these animals should be carefully examined for early lesions on the mouth and hooves. The mouth of any lame animal, and the feet of animals with oral lesions or drooling, should also be checked. Tranquilization may be necessary for a thorough examination as vesicles may be difficult to see. Laboratory testing is an absolute requirement to confirm FMDV infection as all vesicular diseases have almost identical clinical signs.

Differential diagnosis

The clinical signs of foot-and-mouth disease can be similar to vesicular stomatitis, swine vesicular disease, vesicular exanthema of swine, foot rot, and chemical and thermal burns. In cattle, oral lesions seen later in the progression of FMD can resemble rinderpest, infectious bovine rhinotracheitis (IBR), bovine virus diarrhea (BVD), malignant catarrhal fever (MCF), and bluetongue. In sheep, these later lesions can resemble bluetongue, contagious ecthyma, and lip and leg ulceration.

Laboratory tests

FMDV can be identified using enzyme-linked immunosorbent assay (ELISA), complement fixation, and virus isolation. Virus isolation is done by inoculation of primary bovine thyroid cells and primary pig, calf and lamb kidney cells, inoculation of BHK-21 and IB-RS-2 cell lines, or inoculation of mice. ELISA and virus neutralization tests can be used to detect antibodies in serum. Virus isolation and identification must be performed on the initial case. Subsequently, antigen or nucleic acid detection can be used to diagnose additional cases in an outbreak.

Samples to collect

Before collecting or sending any samples from vesicular disease suspects, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent spread of the disease. Since vesicular diseases can not be distinguished clinically, and some are zoonotic, samples should be collected and handled with all appropriate precautions. Samples include vesicular fluid, the epithelium covering vesicles, esophageal-pharyngeal fluid, unclotted whole blood collected from febrile animals and fecal and serum samples from infected and non-infected animals.

Recommended actions if foot-and-mouth disease is suspected

Notification of authorities

A quick response is vitally important in containing an outbreak of foot-and-mouth disease. State and federal veterinarians should be immediately informed of any suspected vesicular disease. Federal: Area Veterinarians

in Charge (AVICS) http://www.aphis.usda.gov/vs/area_offices.htm

State vets: http://www.aphis.usda.gov/vs/sregs/official.html

Quarantine and Disinfection

Suspected animals should be quarantined immediately and the premises should be disinfected. Sodium hydroxide (2%), sodium carbonate (4%), and citric acid (0.2%) are effective disinfectants. Less ideal disinfectants include iodophores, quaternary ammonium compounds, hypochlorite, and phenols, because they rapidly lose the ability to disinfect in the presence of organic matter. There are newer disinfectants that are better than and not as corrosive as some of these listed, included a chlorinated compound, Vircon-S®.

Vaccination

FMD vaccines used as prophylactic in a particular area are of the world, or used for control of an outbreak, must closely match the type and subtype of the prevalent FMDV strain. With seven serotypes, and more than 60 subtypes of FMDV, this task is one of the biggest challenges in FMD vaccination. Currently, there is no universal vaccine against FMD. The U.S., Canada, and Mexico maintain the North American FMD Vaccine Bank which contains vaccine strains for the most prevalent circulating serotypes in the world. The decision to use vaccination in control and eradication efforts is complex and depends upon scientific, economic, political, and societal factors specific to the outbreak situation. The final decision to use vaccination as an aid in controlling an outbreak of FMD in the U.S., Canada, or Mexico would be made by the Chief Veterinary Officer in each country.

Public health

FMDV infections in humans are rare, with just over 40 cases diagnosed since 1921. Vesicular lesions can be seen, but the signs are generally mild. Foot-and-mouth disease is not considered to be a public health problem.

For More Information

World Organization for Animal Health (OIE)

http://www.oie.int

OIE Manual of Standards

http://www.oie.int/eng/normes/mmanual/a_summry.htm

OIE International Animal Health Code

http://www.oie.int/eng/normes/mcode/A_summry.htm

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http://www.vet.uga.edu/vpp/gray_book/FAD/

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Influenza

Flu, Grippe, Swine Influenza, Hog Flu, Pig Flu, Equine Influenza, Avian Influenza

Last Updated: Sept. 13, 2004

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Etiology

Viruses in the family Orthomyxoviridae cause influenza. There are three genera of influenza viruses: influenzavirus A, influenzavirus B and influenzavirus C.[1] These viruses are also called type A, type B and type C. Type A viruses include the avian, swine and equine influenza viruses, as well as the human influenza A viruses. The influenza B and C viruses are mainly found in humans, although there is increasing evidence that they can also infect other species.

Influenza A viruses

Influenza A viruses are classified into subtypes based on two surface antigens, hemagglutinin (H) and neuraminidase (N).

There are 15 hemagglutinin antigens (H1 to H15) and 9 neuraminidase antigens (N1 to N9).[2-7] These two proteins are involved in cell attachment and release from cells, and are also major targets for the immune response.[8-11] Only limited subtypes are found in each species of mammal.[11]

Subtypes of influenza A viruses are classified into strains. Strains of influenza viruses are described by their type, host, place of first isolation, strain number (if any), year of isolation, and antigenic subtype.[11,12] [e.g., the prototype strain of the H7N7 subtype of equine influenza virus, first isolated in Czechoslovakia in 1956, is A/eq/Prague/56 (H7N7).] For human strains, the host is omitted.

Influenza A viruses change frequently. New strains and subtypes can cause epidemics and pandemics. Strains evolve as they accumulate point mutations during virus replication. (antigenic drift).[11] Genetic reassortment can occur if two different influenza viruses infect a cell simultaneously.[10] Reassortment between two different strains results in the periodic emergence of novel strains. Reassortment between subtypes can result in the emergence of a new subtype. Reassortment can occur between avian, swine, equine and human influenza A viruses. This type of reassortment can result in a 'hybrid' virus with, for example, both avian and human influenza virus proteins.

An abrupt change in the subtypes found in host species is called an 'antigenic shift.' Antigenic shifts can result from three mechanisms which include the direct transfer of a whole virus from one host species into another - e.g., an avian influenza virus spreading in pigs, reassortment between subtypes, or the re-emergence of a virus that was found previously but is no longer in circulation.[9,12] For example, human viruses can continue to circulate in pigs and could re-emerge into the human population.[9]

Avian influenza viruses

Avian influenza viruses are found in a wide variety of domestic and wild birds.[3,12,13] They are also isolated occasionally from mammals including humans.[3,5,7,9,12,15-17] Waterfowl, which seem to be the natural reservoirs for the type A influenza viruses, carry all of the known subtypes.[2,7,9,12-20] The predominant subtypes in wild ducks change periodically.[12] Poultry can be infected by a wide variety of subtypes. From 1993 to 2000, subtypes containing H1 to H7 and H9 to H11 were isolated from live bird markets in the northeastern U.S.[21]

Avian influenza viruses are classified as either highly pathogenic avian influenza (HPAI) or low pathogenic avian influenza (LPAI), based on the genetic features of the virus and the severity of disease in poultry.[2,3] To date, only subtypes that contained H5 or H7 have been highly pathogenic; subtypes that contained other hemagglutinins have been found only in the LPAI form.[6,20,22] H5 and H7 LPAI viruses also exist, and can evolve into highly pathogenic strains.[3,19,20] Subtypes found in ratites have included H3N2, H4N2, H4N6, H5N2, H5N9, H7N1, H7N3, H9N2, H10N4 and H10N7.[22] All were of low virulence for chickens. Isolates from cage birds usually contain H3 or H4.[22]

Swine influenza viruses

Swine influenza viruses are found mainly in pigs, but have also been found in other species including humans.[7,9,11,12,23,24] There is less antigenic drift in swine influenza A viruses than in human viruses.[9] The most common subtypes currently found in pigs are H1N1, H1N2 and H3N2.[25] Although the swine influenza viruses found in the U.S. and Europe are the same subtypes, they are actually different viruses.

The 'classical' H1N1 swine influenza virus, found in pigs since 1918, circulates in the U.S.[9,10,12,18] This virus is also found in Asia.[18]

An 'avian-like' H1N1 virus circulates in European pigs.[9,10,18] It seems to be an avian influenza virus that was transmitted whole to pigs and has replaced the classical H1N1 virus.[10,18] A different 'avian-like' H1N1 virus is co-circulating with the classical H1N1 virus in pigs in Asia.[18]

The H3N2 viruses that recently entered pigs in the Midwest are triple reassortants.[10,14,26] They contain hemagglutinin and neuraminidase proteins from a human influenza virus, and internal proteins from the classical swine influenza virus, an avian influenza virus and a human influenza virus.[26]

The H3N2 viruses in Europe and Asia seem to be the result of reassortment between a human H3N2 virus, circulating there in pigs since the 1970s, and the H1N1 'avian-like' virus.[9] These H3N2 viruses contain human N3 and N2 proteins, and internal proteins from the avian virus.[9]

The H1N2 virus in the U.S. is a reassortant of the classical H1N1 swine influenza virus and the triple reassortant H3N2 virus circulating in the U.S.[9]

The H1N2 virus in Europe is a reassortant of a human H1N1 virus and the 'human-like' European H3N2 virus.[9,18]

Equine influenza viruses

Equine influenza viruses mainly infect horses and other Equidae.[4,12,27] There is less antigenic drift in equine viruses than human viruses.[4,11] The two subtypes known to cause disease in horses are H7N7 (equine virus 1) and H3N8 (equine virus 2).[4,11,12] The H7N7 virus is currently extinct or present at only very low levels in some parts of the world.[4,12]

In 1989, a novel strain of equine influenza [A/eq/Jilin/89 (H3N8)] caused a serious epidemic, with high morbidity and mortality rates, in Chinese horses.[4] The virus appears to be an avian influenza virus. A related virus caused influenza in a few hundred horses the following year but there were no deaths. The avian-like virus continued to circulate in horses in China for at least 5 years without further fatalities.

Human influenza viruses

Human influenza viruses are mainly found in humans, but also infect ferrets and sometimes swine.[11,12,18,28-32] H1N1, H1N2 and H3N2 viruses are currently in general circulation in humans.[3,33] The H1N2 viruses appeared in 2001, probably as a result of genetic reassortment between the H3N2 and H1N1 viruses.[33,34] H2N2 viruses circulated in the human population between 1957 and 1968.[12]

Human influenza viruses change frequently as the result of antigenic drift, and occasionally as the result of antigenic shift. Epidemics occur every few years, as a result of small changes in the influenza viruses.[9,35] Human pandemics, resulting from antigenic shift, were most recently reported in 1918, 1957 and 1968.

Influenza viruses in other species

H7N7 and H4N5 viruses, closely related to avian viruses, have been isolated from seals.[12] In 1984, a H10N4 virus was isolated from mink during an epidemic in Sweden.[12] This virus is thought to have been of avian origin. A H5N1 avian influenza virus was recently isolated from sick domestic and zoo cats in Asia.[15,17]

Influenza B viruses

Influenza B viruses are not categorized into subtypes, but are classified into strains.[3]

Influenza B viruses undergo antigenic drift but not antigenic shift.[3] Antigenic drift is slower in influenza B than in influenza A viruses.[12,33] Influenza B viruses can cause epidemics in humans, but have not, to date, been responsible for pandemics.[12] They have also been found in animals.[9,12,23,29,36]

Influenza C viruses

Influenza C viruses are not classified into subtypes, but are classified into strains.[3]Each strain is antigenically stable, and accumulates few changes over time.[37] However, recent evidence suggests that reassortment does occur frequently between different strains of influenza C viruses.[37,38] Type C viruses can cause mild disease in humans, but have never been associated with large scale epidemics.[8,12,35,39] They have also been found in animals.[9,11,12,23,29,39,40-42]

Geographic Distribution

Human and avian influenza viruses are found worldwide.[2,11-13] Avian HPAI viruses have been eradicated from domestic poultry in most developed nations, but are found worldwide in waterfowl.[2] In North America, H3, H4 and H6 viruses are found most often in wild ducks, but H5, H7 and H9 viruses are also found at low levels.[43]

In early 2004, widespread outbreaks of an avian influenza H5N1 (HPAI) virus occurred in poultry in Cambodia, China, Indonesia, Japan, Laos, South Korea,

Thailand and Vietnam.[3] Beginning in June 2004, new outbreaks of a H5N1 (HPAI) virus were reported in poultry in China, Indonesia, Thailand and Vietnam. Human, feline and possibly porcine infections and deaths have been associated with these outbreaks.

Swine influenza is common in North and South America, Europe and Asia and has been reported from Africa.[18,23] Although the subtypes of the swine influenza viruses found in the U.S. and Europe are the same, they are actually different viruses (see 'Etiology').

Only Australia, New Zealand and Iceland are known to be free from equine influenza.[27] The H3N8 subtype is widespread in horse populations.[4] The H7N7 subtype may be either extinct or present at only very low levels in some parts of the world, including the North America and Europe.[4,12,27] It can still be found at low levels in Central Asia.[12]

Transmission

In mammals, the influenza viruses are transmitted in aerosols created by coughing and sneezing, and by contact with nasal discharges, either directly or on fomites.[4,11,12,18,25,33,35] Close contact and closed environments favor transmission. Influenza viruses are relatively labile, but can persist for several hours in dried mucus.[35] In ferrets, *in utero* transmission can occur with high viremia after experimental infection.[32]

In birds, avian influenza viruses are shed in the feces as well as in saliva and nasal secretions; fecal-oral transmission is the most common means of spread.[2,3,11,12] Waterfowl can carry the avian influenza viruses asymptomatically and transmit them to poultry.[2,11] Viruses have also been found in the yolk and albumen of eggs from infected hens.[2] Although these eggs are unlikely to hatch, broken shells could transmit the virus to other chicks in the incubator. Fomites can be important in transmission and flies may act as mechanical vectors.[2,19,20]

Recently, avian influenza H5N1 was reported in domestic and zoo cats during an outbreak in Asia.[15,17] The cats were all thought to have been infected by eating raw infected poultry. Experimental infections were established in cats by intratracheal inoculation with H5N1 viruses and by feeding H5N1-infected chicks.[17]

Avian influenza viruses (H7N2, LPAI) can persist for up to 2 weeks in feces and on cages.[44] They can also survive for up to 32 days at 15–20°C, and at least 20 days at 28–30°C, but are inactivated more quickly when mixed with chicken manure.[44] HPAI viruses can survive indefinitely when frozen.[19] The avian viruses have also been isolated from the water in ponds where ducks swim.[9,12]

Transmission between species

Ordinarily, swine influenza viruses circulate only among pigs, equine influenza viruses among the Equidae, avian influenza viruses among birds, and human influenza viruses among humans. Occasionally, these viruses cross species barriers. Generally, the virus is not well adapted to the new host species and does not undergo sustained transmission.[3,10-12,23]

Transmission of the avian influenza viruses to people is rare, and has been reported only with the H5, H7 and H9 viruses.[3,7] Most infections have been the result of direct contact with infected poultry or fomites; however, during a 2003 outbreak in the Netherlands, three human infections occurred in family members of infected poultry workers.[3,5] The virus subtype was H7N7. No cases of sustained person-to-person transmission with the avian viruses have been reported, to date.

The H5N1 avian influenza viruses may be likely to undergo cross-species transmission. These viruses have been isolated at least 56 times in humans, after contact with infected poultry.[3,9,14,19,20,45] They have also been isolated recently from cats that ate infected poultry.[15,17] Cats, pigs and mice have been experimentally infected.[14,17] In addition, preliminary evidence of natural infections with the H5N1 viruses has been reported for the first time in pigs, in Fujian province, China.[14]

Infections with swine influenza viruses have been reported sporadically in humans in the U.S., Europe and New Zealand.[7,9,12,24,46] One college student transmitted the virus to his roommate, who remained asymptomatic.[24] Limited person-to-person transmission was also reported in 1976, when approximately 500 military recruits in Fort Dix, New Jersey were infected with a swine influenza virus.[9,12,24] This virus spread to a limited extent on the base, which contained approximately 12,000 people, but did not spread to the surrounding community. Recent serologic evidence suggests that swine influenza infections may occur regularly in people who have contact with pigs.[7,9,12] If these infections resemble human influenza, they may not be recognized or reported as caused by a swine influenza virus.

Pigs are readily infected with human influenza A viruses, but most strains do not spread widely.[12] Pigs can also be infected with human influenza B viruses; serologic studies from the U.K. suggest that these infections are sporadic and do not spread to other pigs.[29]

Rarely, transmission between species results in an epidemic in the new host. Generally, this requires a novel hemagglutinin and/or neuraminidase protein to evade the immune response, together with viral proteins that are well adapted to the new host's cells.[10] Occasionally, a virus is transferred whole to the new host and can

spread. This has occurred a few times when avian viruses infected mink, horses, seals and pigs.[4,10,12,16,18] However, dissemination is more likely if the novel virus reassorts with a virus that is already adapted to the host species.[3] Reassortment can occur in the new host's own cells.[3,10,20] It could also occur in an intermediate host, particularly a pig.[3,9,10,20] Pigs have receptors that can bind swine, human, and avian influenza viruses.[7,9,18,25] For this reason, they have been called 'mixing vessels' for the formation of new viruses.

Although reassortment can occur anywhere, many of the new viruses originate in Asia. In rural China and other regions, a variety of species including ducks are kept in close proximity to each other and to humans.[9,12,14] This results in an increased opportunity for virus reassortment.

The last three human pandemics appear to have been the result of reassortments.[10]

The 1957 H2N2 ('Asian flu') virus contained avian hemagglutinin, neuraminidase and an internal protein, and 5 other proteins from a human H1N1 strain.[9,10] The H3N2 'Hong Kong flu' virus of 1968 had two new proteins from an avian virus – the new hemagglutinin and an internal protein - but kept the neuraminidase and remaining proteins from the H2N2 virus.[9,10] The origin of the strain that caused the 1918 human pandemic ('Spanish flu') is uncertain. Although the hemagglutinin protein is more closely related to avian influenza viruses than to human influenza viruses, there is some evidence that this virus may have evolved in an intermediate host before causing an epidemic in humans.[10] Repeated reassortments of human, avian and swine influenza viruses have also resulted in novel swine viruses (see 'etiology' for a description of these viruses).

Reassortant highly pathogenic avian influenza viruses may become progressively more virulent for mammals. From 1999 to 2002, H5N1 avian influenza viruses isolated from healthy ducks in southern China acquired the ability to replicate and cause lethal disease in mice.[14] Most of these viruses appear to be reassortants that contained a hemagglutinin gene related to the A/Goose/Guangdong/1/96 (H5N1) HPAI avian influenza virus and other genes from unknown Eurasian avian influenza viruses.

Disinfection

The influenza viruses are susceptible to a variety of disinfectants including 1% sodium hypochlorite, 70% ethanol, glutaraldehyde, formaldehyde and lipid solvents.[1,11,23,35]They can also be inactivated by heat of 56°C for a minimum of 30 min, radiation or pH 2.[1,11,35,44]

Infections in Humans

Incubation Period

The incubation period is usually short; most infections appear after one to four days.[12,33-35]

Clinical Signs

Uncomplicated infections with the human influenza A or B viruses are usually characterized by upper respiratory symptoms, which may include fever, chills, anorexia, headache, myalgia, weakness, sneezing, rhinitis, sore throat or a nonproductive cough.[8,12,32-35] Diarrhea, abdominal pain and photophobia have also been reported.[8,32] Nausea, vomiting and otitis media are common in children, and febrile seizures have been reported in severe cases.[33,34] In young children, the initial signs may mimic bacterial sepsis.[33] Most people recover in 1 to 5 days but, in some cases, the symptoms may last up to 2 weeks or longer.[8,33,35]

More severe symptoms, including pneumonia, can be seen in individuals with chronic respiratory or heart disease.[8,33-35] Secondary bacterial or viral infections may also occur.[8,12,33,34] In addition, influenza A has been associated with encephalopathy, transverse myelitis, Reye syndrome, myocarditis, pericarditis and myositis.[33,34]

Influenza C viruses are thought to mainly cause a mild upper respiratory disease in children and young adults, but more severe cases similar to influenza A or B have also been reported.[12,37-39] Some infections have resulted in bronchitis or pneumonia.[37] Infections may also be asymptomatic.

Avian influenza infections in humans

Rare infections with avian influenza viruses have been reported in humans. Healthy children and adults, as well as those with chronic medical conditions, have been affected.[20] While some infections have been limited to conjunctivitis and/or typical influenza symptoms, others were serious or fatal.[3,5,9,14,19,20,45,49] Viral pneumonia, acute respiratory distress syndrome, severe bronchointerstitial pneumonia, multiple organ dysfunction and other severe or fatal complications have been reported.[5,20] In one fatal case, the initial symptoms were limited to a persistent high fever and headache, and respiratory disease was not seen until later.[5] The HPAI viruses appear to cause more severe infections than the LPAI viruses.[3]

The following human infections have been reported recently:

- In 1997, eighteen human infections were reported in association with a H5N1 avian influenza virus outbreak in poultry in Hong Kong.[3,9,14,19,20] The symptoms included fever, sore throat and cough

and, in some cases, severe respiratory distress and viral pneumonia.[20] Eighteen people were hospitalized and six died.

- In 1999, avian influenza (H9N2) was confirmed in two children in Hong Kong.[3,14,20] The illnesses were mild and both children recovered. No other cases were found. Six unrelated H9N2 infections were also reported from mainland China in 1998-99; all six people recovered.[3,14]
- In 2002, antibodies to an avian H7N2 virus were found in one person after an outbreak in poultry in Virginia.[3]
- In 2003, two avian influenza H5N1 infections were reported in a Hong Kong family that had traveled to China.[3,14,20] One of the two people died. Another family member died of a respiratory illness while in China, but no testing was done.
- In 2003, 347 total and 89 confirmed human infections were associated with an outbreak of avian H7N7 influenza virus in poultry in the Netherlands.[3,5,14,49] Most cases occurred in poultry workers, but three family members also became ill.[3,5] In 78 of the confirmed cases, conjunctivitis was the only sign of infection.[5] Two people had influenza symptoms such as fever, coughing and muscle aches. Five had both conjunctivitis and influenza-like illnesses. (Four cases were classified as "other.") The single death occurred in an otherwise healthy veterinarian who developed acute respiratory distress syndrome and other complications.[5] His initial symptoms included a persistent high fever and headache but no signs of respiratory disease. The virus isolated from the fatal case had accumulated a significant number of mutations, while viruses from most of the other individuals had not.[5]
- Cases of conjunctivitis have been reported after contact with H7N7 avian viruses in infected seals.5,16
- In 2003, a H9N2 avian influenza virus infection was confirmed in a child in Hong Kong.[3,20] The child was hospitalized but recovered.
- In 2003, a H7N2 infection with respiratory signs was reported in a patient in New York.[3] The person, who had serious underlying medical conditions, was hospitalized but recovered.
- In 2004, two cases of conjunctivitis and flu-like symptoms were confirmed in poultry workers in Canada.[45] Both people recovered after treatment with an antiviral drug. Ten other infections were suspected but not confirmed; these cases included both conjunctivitis and upper respiratory symptoms. All of the infections were associated with a H7N3 virus outbreak in poultry.
- In 2004, human illness and deaths have been associated with widespread outbreaks of avian influenza (H5N1) among poultry in Asia. Twenty-two cases and 15 deaths were confirmed in Vietnam, and 12 cases with 8 deaths in Thailand through February 2004.[3] Deaths were not reported in other countries. An additional 3 deaths were reported in Vietnam in August, in association with new outbreaks of HPAI (H5N1) virus among poultry in China, Indonesia, Thailand and Vietnam.[45]

Swine influenza virus infections in humans

Although serologic evidence suggests that zoonotic infections with swine influenza viruses may not be uncommon, relatively few infections have been documented.[7] It is unknown whether infections with swine influenza viruses differ significantly from infections with human influenza viruses.[7]

Reported cases of influenza caused by swine influenza viruses include the following:

- A self-limiting illness with flu symptoms was reported in a college student.[24] There was evidence that his roommate had been infected but remained asymptomatic.
- An infection with flu symptoms including diarrhea was reported in a young boy, who recovered.[24] There was no evidence of spread to his family.
- Swine influenza virus was isolated from an immunocompromised child with pneumonia who died.[46] Serologic evidence of possible infection was found in five contacts, but the infection did not spread further.
- A localized outbreak was reported at Fort Dix, New Jersey. A swine influenza virus was isolated from 5 recruits with respiratory disease, including one who died of pneumonia.[9,12,24] Serologic evidence suggested that approximately 500 people on the fort had also been infected by person-to-person spread.

Equine influenza virus infections in humans

Antibodies to the equine H3N8 viruses have been reported in humans.[12] Human volunteers inoculated with an equine virus became ill, and virus could be isolated for up to 10 days.[12]

Communicability

The human influenza viruses are readily transmitted from person to person. Infected adults usually begin to shed influenza A viruses the day before the symptoms appear, and are infectious for 3 to 5 days after the initial signs.[33,35] Young children can shed virus for up to 6 days before, and more than 10 days after they become ill.[33,34] Severely immunocompromised individuals may remain infectious for weeks to months.[33,34] Humans can transmit influenza viruses to ferrets and, occasionally, to swine.[11,12,28,31]

Rare cases of person-to-person spread, including a localized outbreak among recruits at a military base, have been reported in humans infected with swine influenza viruses.[9,12,24] Rare cases of probable person-to-person transmission, and no cases of sustained transmission, have been reported in humans infected with the avian influenza viruses.[3,5]

Diagnostic Tests

In humans, influenza A and B can be diagnosed by virus isolation, detection of antigens or nucleic acids, or retrospectively by serology. The viruses can be isolated in cell lines or chicken embryos, and are identified by hemagglutination inhibition tests.[8,12] Antigens can be detected in respiratory secretions by immunofluorescence or ELISAs.[8,34] Commercial rapid diagnostic test kits (Directigen® Flu A test) can provide a diagnosis within 30 minutes.[34] PCR techniques are also available.[33,34] Serologic tests include complement fixation, hemagglutination inhibition, and immunodiffusion.[8,12,34] A rising titer is necessary to diagnose influenza by serology.

Avian influenza viruses can be identified by PCR, antigen detection or virus isolation.[3] In the U.S., samples that test positive by PCR or antigen tests are confirmed by the Centers for Disease Control and Prevention (CDC). PCR and antigen testing of avian influenza viruses must be carried out in Biosafety Level (BSL) 2 laboratory conditions.[3] BSL 3+ laboratory conditions are needed for isolation of the HPAI viruses.[3]

Treatment

Four antiviral drugs are available for influenza treatment in the U.S. Amantadine and rimantadine are active against influenza A viruses, if treatment is begun within the first 48 hours.[8,33,35,50] Zanamivir and oseltamivir are effective for both influenza A and influenza B.[33,50] Treatment usually results in milder symptoms and recovery, on average, one day sooner.[8,33,50]

Drug resistance develops rapidly in viruses exposed to amantadine or rimantadine, and may emerge during treatment.[8,12,33] Some of the H5N1 viruses isolated in 2004 in Asia have been resistant to amantadine and rimantadine. Laboratory studies have shown that influenza viruses can also become resistant to zanamivir and oseltamivir.[33,50]

Prevention

An annual vaccine is available for influenza A and B.[8,12] Both inactivated (injected) and live (intranasal) vaccines may be available.[33] The vaccine is given in the fall before the flu season.[8] It contains the strains of viruses thought most likely to produce epidemics during the following winter, and is updated annually. Details on vaccine efficacy, vaccine types, and recommendations for vaccination in specific population groups are available from the CDC.[34]

Three antiviral drugs - amantadine, rimantadine and oseltamivir - can be used for prophylaxis in high risk populations such as the elderly or immunocompromised.[33,34,50]

Other preventative measures include avoidance of contact with people with symptomatic disease, as well as hand washing and other hygiene measures. People with influenza should avoid contact with ferrets.[31] If contact is unavoidable, they should wear gloves and face masks to prevent transmitting the virus to the animal.[28]

Preventative measures for the avian influenza viruses

The control of epidemics in poultry decrease the risk of exposure for humans.[20] People working with infected birds should follow good hygiene practices and wear protective clothing, including boots, coveralls, gloves, face masks and headgear.[19,20] In addition, the World Health Organization (WHO) recommends prophylaxis with antiviral drugs in people who cull birds infected with H5N1 HPAI viruses.[20]

To prevent reassortment between human and avian influenza viruses, people in contact with infected birds should be vaccinated against human influenza.[10,20] They are also discouraged from having contact with sick birds while suffering flu symptoms.[10]

Morbidity and Mortality

Although the morbidity rates for influenza are high, uncomplicated infections with the human viruses are rarely fatal in healthy individuals.[8,10,12,32,35] Infections are more severe in the elderly, young children (particularly infants), people with respiratory or cardiac disease, and those who are immunosuppressed.[8,33-35] Influenza-related deaths are usually the result of pneumonia or the exacerbation of a cardiopulmonary condition or other chronic disease.[34] Over 90% of these deaths occur in the elderly.[33] The estimated mortality rate from influenza is 0.0004-0.0006% in persons from 0-49 years old, 0.0075% between the ages of 50 and 64, and 0.1% in those over 65.[33,34] Deaths are rare in children, but can occur.[33,34] Immunity to the viral surface antigens reduces the risk of infection and severity of disease. Antibodies offer limited or no protection against other virus types or subtypes.[33]

Human influenza can occur as a localized outbreak, an epidemic, a pandemic, or as sporadic cases.[10] Although a new virus may spread among a population before the "flu season," epidemics in temperate regions usually do not begin until after school starts in the fall.[8] During a typi-

cal epidemic, influenza appears first among school-aged children, then spreads to preschool children and adults.[8,12] During epidemics, 15% to 40% of the population may be infected.[10,12] The outbreak usually lasts for 3 to 6 weeks.[8,12] Epidemics in tropical regions are not usually seasonal.[12]

Antigenic drift is usually responsible for small scale epidemics and localized outbreaks.[9] In North America, an epidemic of influenza A usually occurs every 1 to 3 years, and an epidemic of influenza B every 3 to 4 years.[35] Since 1968, the type A (H3N2) viruses have caused the most serious outbreaks with the highest mortality rates.[33,34] Influenza C viruses cause sporadic cases of influenza and minor localized outbreaks, but have not, to date, been associated with epidemics.[8,12,35,39]

Severe pandemics, which last occurred in 1918, 1957 and 1968, are caused by antigenic shifts in influenza A viruses.[8,10] During influenza pandemics, the morbidity and mortality rates can increase dramatically in all age groups.[3,8,9,12,18,34] In the most severe pandemic, in 1918, the morbidity rate was 25-40% and the case fatality rate 2-5%.[10] Approximately 500,000 deaths were reported in the U.S. and an estimated 20-50 million deaths worldwide.[3,8-10,12,18] After a pandemic, an influenza virus usually becomes established in the population and circulates for years.[3]

Zoonotic influenza

Human infections with avian influenza viruses are rarely reported. The severity of the disease seems to depend on the virus subtype and strain. More severe infections have been reported with the HPAI viruses, particularly H5N1. From 1997 to 2004, there were at least 56 confirmed H5N1 virus infections, and 33 of these cases were fatal.[3,9,14,19,20,45] Human disease has also been reported after infections with H7N2, H7N3, H7N7 and H9N2 viruses.[3,5,14,16,45,49] Most infections with the H7 viruses have been limited to conjunctivitis, but influenza symptoms have also been seen. A single death was seen in an otherwise healthy veterinarian who became infected with a H7N7 virus.[5]

Most humans infected with the swine influenza viruses have had mild disease or been asymptomatic, but three deaths were reported: one in a young boy who was immunosuppressed, one in a military recruit and one in a pregnant woman who developed pneumonia.[9,12,24,46] During the only known outbreak, on a military base in New Jersey, the swine influenza virus was isolated from 5 people with respiratory disease, including one who died of pneumonia, and serologic evidence of infection was found in approximately 500 of 12,000 people on the base.[9,12,24] Serologic evidence also suggests that people who work with pigs are occasionally infected with swine influenza viruses, but these infections may not be reported if they resemble human influenza.[7,9,12]

Infections in Animals

Species Affected

Influenza A Viruses

Influenza A viruses can cause disease in birds, swine, horses, ferrets, mink, seals, whales, humans and other species.

Avian influenza viruses mainly infect birds, but can also cause disease in horses, swine, mink, cats, marine mammals and humans.[3,4,9,10,12,15-18] Waterfowl appear to be the natural reservoirs for the influenza A viruses.[2,9,12,18,20] Most, but not all, infections in wild birds are asymptomatic.[2,3,9,12] Poultry can develop serious or mild disease, depending on the subtype and strain of virus.[2,22] In cage birds, most infections have been recorded in passerine birds.[22] Psittacine birds are rarely affected.

Swine influenza viruses mainly affect pigs but can also cause disease in turkeys and humans.[7,11,12,23]

Equine influenza viruses mainly affect horses, donkeys and other Equidae.[4,27] Antibodies to the equine H3N8 viruses have been reported in humans.[12]

Human influenza viruses mainly cause disease in humans and ferrets.[28,30-32] They can also infect pigs and have been reported in dogs, cattle and birds.[11,12,29] Experimental infections have been reported in horses.[12]

Influenza B viruses

Influenza B viruses can cause disease in humans, ferrets and seals, however these viruses have also been isolated from pigs and a horse.[9,12,23,36] Serologic evidence of infection has been found in pigs, dogs and horses.[12,29]

Influenza C viruses

Influenza C viruses have been isolated from humans and swine.[9,11,12,23,39,40] These viruses can cause disease in experimentally infected dogs.[12] Serologic evidence of infection has been found in pigs, dogs and horses.[12,29,41,42]

Incubation Period

The incubation period is generally short. The clinical signs usually appear within 1 to 3 days in horses, pigs or seals.[4,11,12,23,25,27,47] Rarely, incubation periods up to 7 days have been reported in some horses.[27] In poultry, the incubation period can be a few hours to a week.[2,11,13]

Clinical Signs

Avian influenza

The highly pathogenic avian influenza (HPAI) viruses cause severe disease in poultry. These viruses can cause serious infections in some species of birds on a farm

while leaving others unaffected.[2,12] The clinical signs are variable.[2,6,11,22] The typical symptoms are those of a respiratory disease with sinusitis, lacrimation, edema of the head, cyanosis of the head, comb and wattle, and green to white diarrhea.[2,6,11,13,19] Hemorrhagic lesions may be found on the comb and wattles of turkeys.[2,11] Other signs may include anorexia, coughing, sneezing, blood-tinged oral and nasal discharges, ecchymoses on the shanks and feet, neurologic disease, decreased egg production, loss of egg pigmentation and deformed or shell-less eggs.[2,11-13, 19] Sudden death may occur with few other signs.[6] Most of the flock usually dies.[2] In ducks, the most common symptoms are sinusitis, diarrhea and increased mortality.[2,11]

The low pathogenic (LPAI) viruses usually cause subclinical or mild illness.[22] The symptoms may include decreased egg production or increased mortality rates.[3,13] More severe disease, mimicking highly pathogenic avian influenza, can be seen if the birds are concurrently infected with other viruses or there are other exacerbating factors.[6,22]

Turkeys infected with swine influenza viruses may develop respiratory disease, have decreased egg production, or produce abnormal eggs.[11]

Avian influenza is often subclinical in wild birds, but some strains can cause illness and death.[2,3,9,12]

Swine influenza

Swine influenza is an acute upper respiratory disease characterized by fever, lethargy, anorexia, weight loss and labored breathing.[9,11,12,23,25] Coughing may be seen in the later stages of the disease.[9] Sneezing, nasal discharge and conjunctivitis are less common symptoms.[9] Abortions may also occur.[23,25] Some virus strains can circulate in pigs with few or no clinical signs.[9,12,18] Recovery usually occurs after 3 to 7 days.[9,11,23]

Complications may include secondary bacterial or viral infections.[9,25] Severe, potentially fatal bronchopneumonia is occasionally seen.[11]

Equine influenza

Equine influenza usually spreads rapidly in a group of animals. In naïve horses, the first sign is usually a fever, followed by a deep, dry cough.[4] Other symptoms may include a serous to mucopurulent nasal discharge, myalgia, inappetence and enlarged submandibular lymph nodes.[4,11,12,27] There may be edema of the legs and scrotum, and spasmodic impaction colic has been reported.[4,27] Animals with partial immunity can have milder, atypical infections with little or no coughing or fever.[4]

Healthy adult horses usually recover within 1-2 weeks, but the cough may persist longer.[4,12,27] Secondary bacterial infections prolong recovery.[4,11,27] Death in adult horses usually results from bacterial pneumonia, pleuritis or purpura hemorrhagica.[4] Sequelae may include chronic pharyngitis, chronic bronchiolitis and emphysema.[4,27] Interstitial myocarditis can occur during or after the infection.[12] Young foals without maternal antibodies can develop a rapidly fatal viral pneumonia.[4,12]

Horses experimentally infected with human influenza virus (H3N2 'Hong Kong') developed a mild febrile illness.[12] The virus could be isolated for up to 5 days.

Influenza in ferrets

Ferrets are susceptible to the human influenza viruses. The symptoms may include fever, anorexia, depression, listlessness, sneezing, purulent nasal discharge and coughing.[28,30,32] The infection is not usually fatal in adult animals, which generally recover in 5 days to 2 weeks.[28,31,32] More severe or fatal disease can be seen in neonates.[32]

Influenza in mink

In 1984, a H10N4 avian influenza virus caused an epidemic on 33 mink farms in Sweden.[12] The symptoms included anorexia, sneezing, coughing, nasal and ocular discharges, and numerous deaths.

H5N1 influenza in cats

Influenza A was recently reported in cats. During an epidemic of H5N1 avian influenza in Asian poultry, there were anecdotal reports of fatal influenza in domestic cats, a white tiger and a clouded leopard.[15] H5N1 avian influenza virus was isolated from these animals, which were all thought to have been infected by eating raw, infected poultry.

Clinical signs in cats experimentally infected with the H5N1 virus included fever, lethargy, conjunctivitis, protrusion of the third eyelid and dyspnea.[17] One cat died on the 6th day after inoculation; the remaining animals were euthanized and necropsied the following day. There was no evidence of infection after inoculation with a human H3N2 virus.[17]

Influenza in marine mammals

Influenza A viruses have been associated with outbreaks of pneumonia in seals and disease in a pilot whale.[12,16,47] The viruses appear to be of avian origin.[16] Clinical signs in seals have included weakness, incoordination, dyspnea and swelling of the neck.[47] A white or bloody nasal discharge was seen in some animals. In the single known case in a whale, the symptoms included extreme emaciation, difficulty maneuvering and sloughing skin.[47]

Influenza in dogs

The clinical signs in dogs experimentally infected with influenza C virus included nasal discharge and conjunctivitis, which persisted for 10 days.[12]

Communicability

Influenza viruses are readily transmitted between animals in the same species. More rarely, they can be transmitted to other species. Pigs may begin excreting influenza viruses within 24 hours of infection and typically shed the viruses for 7 to 10 days.[18,25] Shedding up to 4 months has been documented in one pig.[18] Horses begin excreting the virus during the incubation period and usually excrete the virus for 4 to 5 days or less after the onset of clinical signs.[4,11] Most chickens shed LPAI influenza viruses for only a week, but a minority of the flock can excrete the virus in the feces for up to 2 weeks.[44] Ducks can shed avian influenza viruses for up to 30 days.[9]

Cats experimentally infected with the avian influenza H5N1 virus shed the virus by the third day post-inoculation, and were able to infect two sentinel cats in close contact.[17]

Diagnostic Tests

Avian influenza

Avian influenza is usually diagnosed by virus isolation in embryonated eggs.[6,13] The virus can be isolated from tracheal, oronasal or cloacal swabs in live birds, and pooled or individual organ samples (trachea, lungs, air sacs, intestine, spleen, kidney, brain, liver and heart) from dead birds.[2,6] Feces can be substituted in small birds if cloacal samples are not practical. The virus is subtyped with immunodiffusion tests, or hemagglutination and neuraminidase inhibition tests.[6] Virus inoculation into susceptible birds, together with genetic tests, is used to differentiate LPAI from HPAI viruses.[6]

Viral antigens can be detected with ELISAs, including a rapid test (Directigen® Flu A kit, Becton Dickinson Microbiology Systems).[6] Reverse transcription polymerase chain reaction (RT-PCR) tests may be used to identify nucleic acids.[6] Serological tests, including agar gel immunodiffusion, hemagglutination inhibition and ELISAs, may be used as supplemental tests.[6]

Swine influenza

Swine influenza can be diagnosed by virus isolation, detection of viral antigens or nucleic acids, and serology. Mammalian influenza viruses can be isolated in embryonated chicken eggs or cell cultures.[9,25] The swine influenza viruses can be recovered from lung tissues at necropsy, or nasal or pharyngeal swabs from acutely ill pigs.[11,23,25] Recovery is best from an animal with a fever, 24-48 hours after the onset of disease.[25] Isolated viruses are subtyped with hemagglutination inhibition and neuraminidase inhibition tests.[9,25]

Immunofluorescent techniques can detect antigens in fresh lung tissue, nasal epithelial cells or bronchoalveolar lavage.[9,25] Other antigen tests include immunohistochemistry on fixed tissue samples, and ELISAs including the Directigen® Flu A test.[9,25] RT-PCR assays are also available.[9,25]

Serology on paired samples can diagnose swine influenza retrospectively.[23] The hemagglutination inhibition test, which is subtype specific, is most often used.[9,23,25] It may not detect new viruses.[9] ELISA tests are also used. Rarely used serological tests in swine include agar gel immunodiffusion, the indirect fluorescent antibody test and virus neutralization.[25]

Equine influenza

Equine influenza may tentatively be diagnosed based on the clinical signs.[27] As in swine, the disease is confirmed by virus isolation, the detection of viral antigens or nucleic acids, or retrospectively by serology.[4,27] In horses, peak virus shedding is thought to occur during the first 24 to 48 hours of fever.[4]

As in swine, a serological diagnosis requires paired acute and convalescent samples.[4] The most commonly used tests in horses are the hemagglutination inhibition test and a single-radial hemolysis (SRH) test.[4] An ELISA that can distinguish natural from vaccine-induced antibodies is in development.[4]

Treatment

Animals with influenza are usually treated with supportive care and rest.[4,13,23,27] Antibiotics may be used to control secondary infections.[4,13,27] Antiviral drugs are not generally given to animals, but could be of use in valuable horses.[2]

Poultry flocks with highly pathogenic avian influenza are depopulated and are not treated.[3,11]

Prevention

Inactivated influenza vaccines are available for pigs, horses and, in some countries, birds.[4,11,12,23,25,27] The vaccines do not always prevent infection, but the disease is usually milder if it occurs. In the U.S., avian influenza vaccines are used most often in turkeys and are intended only to prevent infection by LPAI viruses.[6] HPAI vaccines are not used routinely in the U.S. or most other countries.[6] A "DIVA" (differentiating infected from vaccinated animals) strategy has been successfully used to control a low pathogenicity avian influenza outbreak in Italy.[48] This strategy depends on using an inactivated vac-

cine containing the homologous H type and a heterologous N type. Vaccinated birds that subsequently become infected can be detected by testing for antibodies to the N type of the field strain.

Influenza vaccines change periodically to reflect the current subtypes and strains in a geographic area. In general, swine and equine viruses display less antigenic drift than human viruses and these vaccines are changed less often.[4,9,11] Avian vaccines are usually autogenous or from viruses of the same subtype or hemagglutinin type.[6]

Poultry can be infected by contact with newly introduced birds or wild birds, particularly waterfowl.[9,11,19,20] The risk of infection can be decreased by all-in/ all-out flock management, and by preventing any contact with wild birds or their water sources.[2,19] Biosecurity measures can prevent the entry of the virus on fomites.[2,19,20] Birds should not be returned to the farm from live bird markets or other slaughter channels.[19]

In pigs and horses, influenza is usually introduced into a facility in a new animal.[9,11,18,23,27] Isolation of newly acquired animals can decrease the risk of transmission to the rest of the herd.[27] The virus usually persists in an infected swine herd and causes periodic outbreaks, but good management can decrease the severity of disease.[9,12,18,23] Infected swine herds can be cleared of influenza viruses by depopulation.[18]

Ferrets can be infected by the human influenza viruses; people with influenza should avoid contact with ferrets.[31] If contact is unavoidable, a face mask and gloves should be worn.[28]

Cats should not be fed poultry infected with the avian influenza viruses.[15]

Prevention of virus transmission during outbreaks

During an outbreak of influenza among mammals, quarantines and isolation of infected animals help prevent virus dissemination.[4,11] Good hygiene can keep the virus from spreading on fomites. Rest decreases virus shedding in horses.[4] Infected facilities should be cleaned and disinfected after the outbreak.

In poultry, outbreaks of highly pathogenic avian influenza are controlled by eradication.[3,11] The outbreak is managed by quarantine, depopulation, cleaning and disinfection, and surveillance around the affected flocks. Strict hygiene is necessary to prevent virus transmission on fomites.

Morbidity and Mortality

The severity of an influenza virus infection varies with the dose and strain of virus and the host's immunity. In mammals, uncomplicated infections are usually associated with high morbidity rates, low mortality rates and rapid recovery.[4,9,11,12,23,25,27] Secondary bacterial infections can exacerbate the symptoms, prolong recovery and result in complications such as pneumonia.

Swine influenza

Influenza is a major cause of acute respiratory disease in finishing pigs. Approximately 25-33% of 6-7 month old finishing pigs and 45% of breeding pigs have antibodies to the classical swine H1N1 virus in the U.S.[12,18] High seroprevalence rates to swine influenza viruses have also been reported in other countries.[9,12,18,29] In addition, pigs can be infected with the human influenza A, B and C viruses.[9,11,12,23,29,39,40,42] In the U.K., a study found antibodies to both swine and human influenza viruses in 14% of all pigs.[18] Approximately 10% of the pigs were seropositive for influenza C viruses, but only sporadic infections with the human influenza B viruses were found.[29] In Japan, a similar study found antibodies to the type C viruses in 19% of pigs.[42]

Swine influenza viruses are usually introduced into a herd in an infected animal, and can survive in carrier animals for up to 3 months.[11,18,23] In a newly infected herd, up to 100% of the animals may become ill but most animals recover within 5 to 7 days if there are no secondary bacterial infections or other complications.[9,11,23,25] In uncomplicated cases, the case fatality rate has ranged from less than 1% to 3%.[11,12]

Once the virus has been introduced, it usually persists in the herd.[9,12,18] Annual outbreaks are often seen, and occur mainly during the colder months.[9,12,18,23] Many of the infections in endemically infected herds are subclinical; typical signs of influenza may occur in only 25% to 30% of the pigs.[9,18] Maternal antibodies decrease the severity of disease in young pigs.[9] Some viruses can infect the herd with few or no clinical signs.[9,12,18]

Influenza epidemics can occur if a virus infects a population without immunity to the virus, or if the infection is exacerbated by factors such as poor husbandry, stress, secondary infections or cold weather.[12,18] In the epidemic form, the virus spreads rapidly in pigs of all ages.[25] In a 1918 epizootic, millions of pigs developed influenza, and thousands of the infections were fatal.[12] Recently, a novel H3N2 entered pigs in the Midwest and has caused serious illness and reproductive losses in sows.[9]

Equine influenza

In horses, influenza outbreaks are not as seasonal as they are in pigs or humans.[4] Most outbreaks are associated with sales, races and other events where horses congregate.[4,11] Widespread epidemics can be seen, with morbidity rates up to 60-90%, in naïve populations. [4,12] In 1987, an equine influenza epidemic in India affected

more than 27,000 animals and killed several hundred.[4] In populations that have been previously exposed, cases are seen mainly in young and newly introduced animals.[4,12]

Unless there are complications, healthy adult horses usually recover within 1-2 weeks, although coughing can persist.[4,12,27] The H3N8 viruses usually cause more severe disease than the H7N7 viruses.[4,12] Deaths are rare in adult horses, and are usually the result of secondary bacterial infections.[4,12,27] Higher mortality rates have been reported in foals, animals in poor condition and donkeys.[4,27] A rapidly fatal viral pneumonia may be seen in young foals with no maternal antibodies.[4,12] In horses, tracheal clearance rates can be depressed for up to a month after infection.[4]

Avian influenza viruses have rarely been reported in horses. In 1989, a novel strain of equine influenza [A/eq/Jilin/89 (H3N8)] caused a serious epidemic in Chinese horses.[4] The morbidity rate was 80% and the mortality rate was 20%. The virus appeared to be an avian influenza virus. A related virus caused influenza in a few hundred horses the following year but there were no deaths. The avian-like virus continued to circulate in horses for at least 5 years without further fatalities.

Influenza in other mammals

In 1984, an outbreak with an avian H10N4 virus was reported on Swedish mink farms. The outbreak affected 33 farms and killed 3,000 mink.[12] The morbidity rate was nearly 100%.

Fatal infections with an avian H5N1 virus were recently reported in 3 domestic cats, a white tiger and a clouded leopard.[15] Experimental infections were also reported in 8 cats.[17] The morbidity and mortality rates are unknown. Cats inoculated with a human H3N2 virus had no evidence of virus replication or disease.[17]

In seals, the case fatality rate was estimated to be 20% in one outbreak with a H7N7 virus, and 4% in an outbreak with a H4N5 virus.[12] Explosive epidemics in seals are thought to be exacerbated by high population densities and unseasonably warm temperatures.[47]

Avian influenza

Avian influenza outbreaks occur in most countries including the U.S. Low pathogenic forms are seen most often, but outbreaks with the highly pathogenic H5 and H7 viruses are also reported periodically.[2,3] In poultry, HPAI viruses are associated with very high morbidity and mortality rates, up to 90-100%.[2,3] Any surviving birds are usually in poor condition. LPAI viruses usually result in mild or asymptomatic infections, but may also mimic HPAI viruses.[6,22]

Symptomatic infections and outbreaks have been reported in wild birds, but are unusual.[2,3,9,12]

Post-Mortem Lesions

Avian influenza

The lesions in poultry are highly variable and can resemble other avian diseases.[2] There may be subcutaneous edema of the head and neck, fluid in the nares and oral cavity, and severe congestion of the conjunctivae. Hemorrhagic tracheitis can be seen in some birds; in others, the tracheal lesions may be limited to excess mucoid exudate. Petechiae may be found throughout the abdominal fat, serosal surfaces and peritoneum. Hemorrhages may also be seen on the mucosa of the proventriculus, beneath the lining of the gizzard, and in the intestinal mucosa. The kidneys can be severely congested and are sometimes plugged with urate deposits. The ovaries may be hemorrhagic or degenerated, with areas of necrosis. The peritoneal cavity often contains yolk from ruptured ova. Severe airsacculitis and peritonitis may be seen in some birds. In birds that die peracutely and in young birds, the only lesions may be severe congestion of the musculature and dehydration.

Swine influenza

In uncomplicated infections, the gross lesions are mainly those of a viral pneumonia.[9] Affected parts of the lungs are depressed and consolidated, dark red to purple-red, and sharply demarcated.[9,23] The lesions may be found throughout the lungs but are usually more extensive in the ventral regions.[9] Other parts of the lungs may be pale and emphysematous.[23] The airways are often dilated and filled with mucopurulent or blood-tinged, fibrinous exudate.[23] The bronchial and mediastinal lymph nodes are typically enlarged.[9,23] Severe pulmonary edema, or serous or serofibrinous pleuritis may also be seen.[23] Some strains of swine influenza viruses produce more marked lesions than others.[9] Generalized lymphadenopathy, hepatic congestion and pulmonary consolidation were reported in one outbreak of severe disease in swine.[12]

Equine influenza

Interstitial pneumonia, pleuropneumonia, bronchitis, perivasculitis and interstitial myocarditis have been reported in fatal cases in horses.[27]

Influenza in cats

The lesions reported in experimentally infected cats were multiple to coalescing foci of pulmonary consolidation.[17] The lesions were similar whether the cats were infected intratracheally or by the ingestion of infected chicks.

Influenza in marine mammals

In seals, pneumonia with necrotizing bronchitis, bronchiolitis and hemorrhagic alveolitis have been reported.[16,47] In a single case in a whale, the lungs were hemorrhagic and a hilar lymph node was greatly enlarged.[47]

Internet Resources

Animal Health Australia. The National Animal Health Information System (NAHIS) http://www.aahc.com.au/nahis/disease/dislist.asp

Centers for Disease Control and Prevention (CDC) http://www.cdc.gov/flu/

Material Safety Data Sheets–Canadian Laboratory Center for Disease Control http://www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/index.html#menu

Medical Microbiology http://www.gsbs.utmb.edu/microbook

OIE Manual of diagnostic tests and vaccines for terrestrial animals http://www.oie.int/eng/normes/mmanual/a_summry.htm

Prevention and control of influenza. Recommendations of the Advisory Committee on Immunization Practices (ACIP) http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5306a1.htm

The Merck Manual http://www.merck.com/pubs/mmanual/

The Merck Veterinary Manual http://www.merckvetmanual.com/mvm/index.jsp

USAHA Foreign Animal Diseases book http://www.vet.uga.edu/vpp/gray_book/FAD/

World Organization for Animal Health (OIE) http://www.oie.int/

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Newcastle Disease

Last Updated: Dec. 4, 2003

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Importance

Newcastle disease produces a wide range of clinical signs in avian species, from mild to severe. Exotic Newcastle disease (END), the most severe form with neurologic and gastrointestinal signs, is not endemic in the United States. Frequent outbreaks do occur in the U.S. due to illegal importation of exotic birds. The disease is highly contagious and can have high mortality rates. Chickens are highly susceptible and economic losses can be significant.

Etiology

Newcastle disease viruses are classified in the serotype group avian paramyxovirus type 1 (APMV–1) in the genus Rubulavirus, family Paramyxoviridae. There are nine avian paramyxovirus serotypes designated APMV–I to APMV–9.

Species affected

Many avian species are affected by Newcastle disease viruses. Of poultry, chickens are the most susceptible, ducks and geese are the least. Inapparent infections and carrier states can occur in psittacine and some wild bird populations.

Geographic distribution

Exotic Newcastle disease is endemic in many parts of the world including countries in Asia, the Middle East, Africa, and Central and South America. Some countries in Europe are free of the disease. The United States and Canada have seen high mortality in wild cormorants caused by END. There was an outbreak of END in the US in 2003 in southern California.

Transmission

Transmission can occur by direct contact with feces and respiratory discharges or by contamination of the environment including food, water, equipment, and human clothing. Newcastle disease viruses can survive for long periods in the environment, especially in feces. Generally, virus is shed during the incubation period and for a short time during recovery. Some psittacine species can shed the virus intermittently for a year or more. Virus is present in all parts of the carcass of an infected bird.

Incubation period

The incubation period for Newcastle disease can vary from 2–15 days depending on the severity of the strain and the susceptibility of the population. In chickens with the velogenic form, an incubation period of 2–6 days is common.

Clinical signs

Newcastle disease virus strains used to be grouped into pathotypes based on their clinical signs and virulence. These pathotypes included: asymptomatic enteric, which is generally subclinical; lentogenic or respiratory, which has mild or subclinical respiratory signs; mesogenic, which has respiratory and occasional neurologic signs with low mortality; and velogenic, which is the most virulent pathotype with high mortality rates. The velogenic pathotype is divided into a neurotropic form, which has respiratory and neurologic signs, and a viscerotropic form with hemorrhagic intestinal lesions. This classification is not always that clear–cut and many strains have varied manifestations in different birds. In addition, less pathogenic strains can produce severe clinical signs depending on secondary infections or environmental factors.

The OIE provides a clearer definition for the reporting of any case of Exotic Newcastle as: "Newcastle disease is defined as an infection of birds caused by a virus of avian paramyxovirus serotype 1 (APMV–1) that meets one of the following criteria for virulence:

a. The virus has an intracerebral pathogenicity index (ICPI) in day–old chicks (Gallus gallus) of 0.7 or greater.

Or,

b. Multiple basic amino acids have been demonstrated in the virus (either directly or by deduction) at the C–terminus of the F2 protein and phenylalanine at residue

117, which is the N–terminus of the F1 protein. The term 'multiple basic amino acids' refers to at least three arginine or lysine residues between residues 113 and 116. Failure to demonstrate the characteristic pattern of amino acid residues as described above would require characterization of the isolated virus by an ICPI test."

More specific clinical signs that can be seen with END, particularly in chicken flocks, include an initial drop in egg production followed by numerous deaths within 24–43 hours. Deaths in the flock may continue for 7–10 days. Birds that survive for 12–14 days usually live but may have permanent neurological damage including paralysis, and reproductive damage causing decreased egg production. Viscerotropic strains may cause edema of the head, especially around the eyes, and greenish–dark watery diarrhea. Respiratory and neurological signs can also be seen, though these are not as severe as with the neurotropic form. The neurotropic strains cause respiratory signs of gasping and coughing followed by neurological signs which may include muscle tremors, drooping wings, dragging legs, twisting of the head and neck, circling, depression, inappetence, or complete paralysis. There is generally no diarrhea with the neurotropic form. Clinical signs associated with the various strains can be different in species other than chickens. Psittacines and pigeons may show neurologic signs when infected with the viscerotropic strain. Finches and canaries may show no signs of disease at all. Vaccinated birds will have less severe signs.

Post mortem lesions

There are no specific diagnostic post mortem lesions seen with Newcastle disease. A tentative diagnosis can be made with the examination of several carcasses. Gross lesions can be very similar to highly pathogenic avian influenza; therefore, laboratory isolation and identification is important in definitive diagnosis. Lesions may include edema of the interstitial tissue of the neck, especially near the thoracic inlet, and congestion and sometimes hemorrhages on the tracheal mucosa. Petechiae and small ecchymoses may be found on the mucosa of the proventriculus, especially around the orifices of the mucous glands. Additional lesions may include edema, hemorrhages, necrosis, or ulcerations of lymphoid tissue in the intestinal wall mucosa (including Peyer's patches), as well as edema, hemorrhages, or degeneration of the ovaries.

Morbidity and Mortality

Morbidity and mortality rates can vary greatly depending on the virulence of the virus strain and susceptibility of the host. Environmental conditions, secondary infections, vaccination history, and host species all affect these rates. In chickens, morbidity can be up to 100% with 90% mortality. In other species such as finches and canaries, clinical signs may not be present.

Diagnosis

Clinical

Newcastle disease may be suspected, especially in chicken flocks, with a sudden decrease in egg production, high morbidity and mortality, and the characteristic signs and gross lesions; however, due to the wide variety of signs and similarities to other avian diseases, particularly fowl cholera and highly pathogenic avian influenza, definitive diagnosis requires virus isolation and identification in the laboratory.

Differential diagnosis

Differentials include fowl cholera, highly pathogenic avian influenza, laryngotracheitis, coryza, fowl pox (diphtheritic form), psittacosis (chlamydiosis in psittacine birds), mycoplasmosis, infectious bronchitis, Pacheco's disease (seen in psittacine birds), as well as management problems such as deprivation of water, feed or poor ventilation.

Laboratory tests

Samples for virus isolation are inoculated into 9–11 day old embryonated chicken eggs. Chorioallantoic fluid of dead embryos can then be tested for hemagglutination activity and hemaglutination–inhibition. Further tests may be performed to determine pathogenicity and virus strain. Tests available for serology include hemagglutination–inhibition and enzyme–linked immunosorbent assay (ELISA). Vaccination and previous exposure to disease may affect serology results.

Samples to collect

Before collecting or sending any samples from animals with a suspected foreign animal disease, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent the spread of the disease. Newcastle disease is zoonotic; samples should be collected and handled with all appropriate precautions.

Swabs can be taken for virus isolation from the trachea and cloaca of live birds, or tissue samples from dead birds including trachea, lung, spleen, cloaca and brain. Feces can also be used for culture. Cell culture broth such as brain and heart infusion broth with high levels of antibiotics should be used for transport. Samples may be pooled in one broth tube if multiple animals are to be tested. Culture tubes should be kept on ice if they will reach the laboratory within 24 hours; otherwise the samples should be quick–frozen and not allowed to thaw during transport. Clotted blood or serum samples can be submitted for serology.

Recommended actions if Newcastle Disease is suspected

Notification of authorities

State and federal veterinarians should be immediately informed of any suspected cases of Newcastle disease. Federal: Area Veterinarians in Charge (AVICS) http://www.aphis.usda.gov/vs/area_offices.htm

State vets: http://www.aphis.usda.gov/vs/sregs/official.html

Quarantine and Disinfection

Recommendations for the control and eradication of Newcastle disease include strict quarantine, slaughter and disposal of all infected and exposed birds, and disinfection of the premises. The reintroduction of new birds should be delayed for 30 days. Pests such as insects and mice should be controlled, human traffic should be limited, and the introduction of new animals with unknown health status should be avoided. Vaccines are available, though they may interfere with testing. Effective disinfectants include the cresylics and phenolics.

Public health

People can be infected with velogenic Newcastle disease and have signs of conjunctivitis which resolve quickly, with virus shed in the ocular discharges for 4–7 days. Infected individuals should avoid direct and indirect contact with avian species during this time. Laboratory workers and vaccination crews are most at risk, with poultry workers rarely being infected. No known infections have occurred from handling or consuming poultry products.

For More Information

World Organization for Animal Health (OIE)

http://www.oie.int

OIE Manual of Standards

http://www.oie.int/eng/normes/mmanual/a_summry.htm

OIE International Animal Health Code

http://www.oie.int/eng/normes/mcode/A_summry.htm

USAHA Foreign Animal Diseases book

http://www.vet.uga.edu/vpp/gray_book/FAD/

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Rift Valley Fever

Infectious enzootic hepatitis of sheep and cattle

Last Updated: Jan. 2004

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Etiology

Rift Valley fever results from infection by the Rift Valley fever virus, an RNA virus in the genus Phlebovirus (family Bunyaviridae).

Geographic Distribution

Rift Valley fever is found throughout most of Africa. Outbreaks occur at irregular intervals in southern and eastern Africa, as well as in Egypt, Saudi Arabia and Yemen.

Transmission

Rift Valley fever is transmitted by mosquitoes and is usually amplified in ruminant hosts. The virus appears to survive in the dried eggs of *Aedes* mosquitoes; when these mosquitoes hatch during wet years, epidemics can occur. *Aedes* and other species of mosquitoes can transmit infections from the amplifying hosts. Ticks and biting midges may also be able to spread the virus. Humans do not seem to be infected by contact with live hosts, but can be infected by aerosols or direct contact with tissues during parturition, necropsy, slaughter, laboratory procedures or meat preparation for cooking. The Rift Valley fever virus can be found in raw milk. It is also likely to be present in semen; therefore, sexual transmission may be possible.

Under optimal conditions, the Rift Valley fever virus remains viable in aerosols for more than an hour at 25o C. In a neutral or alkaline pH, mixed with serum or other proteins, the virus can survive for as long as 4 months at 4o C and 8 years below 0o C. It is quickly destroyed in decomposing carcasses by pH changes.

Disinfection

The Rift Valley fever virus is susceptible to low pH, lipid solvents and detergents, ether, chloroform and solutions of sodium or calcium hypochlorite with a residual chlorine content greater than 5000 ppm.

Infections in Humans

Incubation Period

In humans, the incubation period is 2 to 6 days.

Clinical Signs

Infection with the Rift Valley fever virus usually results in an asymptomatic infection or a relatively mild illness with fever and liver abnormalities. The symptoms of uncomplicated infections may include fever, headache, generalized weakness, dizziness, weight loss, myalgia and back pain. Some patients also have stiffness of the neck, photophobia and vomiting. Most people recover spontaneously within 2 days to a week.

Complications - hemorrhagic fever, meningoencephalitis or ocular disease - occur in a small percentage of patients. Hemorrhagic fever usually develops 2 to 4 days after the initial symptoms. The symptoms may include jaundice, hematemesis, melena, a purpuric rash, petechiae and bleeding from the gums. Hemorrhagic fever may progress to frank hemorrhages, shock and death.

Ocular disease and meningoencephalitis are usually seen one to three weeks after the initial symptoms. The ocular form is characterized by retinal lesions and may result in some degree of permanent visual impairment. Death is rare in cases of ocular disease or meningoencephalitis.

Communicability

Virus titers in infected humans are high enough to infect mosquitoes and introduce Rift Valley fever into new areas. Virus can be found in the blood and tissues.

Diagnostic Tests

The Rift Valley fever virus can be isolated from the blood, brain, liver or other tissues; in living hosts, viremia is usually seen only during the first three days of fever. The virus can be grown in numerous cell lines including baby hamster kidney cells,

monkey kidney (Vero) cells, chicken embryo reticulum, and primary cultures from cattle or sheep. Hamsters, adult or suckling mice, embryonated chicken eggs or 2-day–old lambs can also be used.

Virus antigens can be detected in blood and tissue samples by various tests including reverse transcription polymerase chain reaction (RT-PCR) testing. Enzyme-linked immunoassay (ELISA) and other serologic assays can detect specific IgM or rising titers.

Treatment and Vaccination

No specific treatment, other than supportive care, is available; however, ribavirin has been promising in animal studies. Interferon, immune modulators and convalescent-phase plasma may also prove to be helpful. Most cases of Rift Valley fever are relatively brief and mild illnesses and may not require treatment.

A human vaccine has been developed and other vaccines are in earlier stages of investigation. None of these vaccines are sold commercially, but one may be available from government sources for people who are occupationally exposed.

Morbidity and Mortality

Humans are highly susceptible to Rift Valley fever. Most cases develop in veterinarians, abattoir workers and others who work closely with blood and tissue samples of animals. During outbreaks in animals, mosquitoes may spread the virus to humans and cause epidemics. In Egypt, approximately 200,000 human cases and 598 deaths occurred during a 1977 epidemic.

Most people with Rift Valley fever recover spontaneously within a week. Ocular disease is seen in approximately 0.5 to 2% and meningoencephalitis and haemorrhagic fever in less than 1%. The case fatality rate for hemorrhagic fever is about 50%. Deaths rarely occur in cases of eye disease or meningoencephalitis but 1 to 10% of patients with ocular disease have some permanent visual impairment. The overall case fatality rate for all patients with Rift Valley fever is less than 1%.

Infections in Animals

Species Affected

Rift Valley fever can affect many species, including sheep, cattle, goats, buffalo, camels, monkeys, gray squirrels and other rodents. The primary amplifying hosts are sheep and cattle. Viremia without severe disease may be seen in adult cats, dogs, horses and some monkeys, but severe disease can occur in newborn puppies and kittens. Rabbits, pigs, guinea pigs, chickens and hedgehogs do not become viremic.

Incubation Period

The incubation period can be as long as 3 days in sheep, cattle, goats and dogs. In newborn lambs, it is 12 to 36 hours. Experimental infections usually become evident after 12 hours in newborn lambs, calves, kids and puppies.

Clinical Signs

The clinical signs vary with the age, species and breed of the animal. In endemic regions, epidemics of Rift Valley fever can be recognized by the high mortality in newborn animals and abortions in adults.

Rift Valley fever is usually most severe in young animals. In young lambs, a biphasic fever, anorexia and lymphadenopathy may be followed by weakness and death within 36 hours; hemorrhagic diarrhea or abdominal pain can also occur. The mortality rate may reach 90 to 100% in neonates. Disease is similar in young calves: fever, anorexia and depression are typical, with mortality rates of 10 to 70%.

The symptoms in adult sheep may include fever, a mucopurulent nasal discharge (sometimes bloodstained), hemorrhagic or foul-smelling diarrhea, vomiting, jaundice, abortion and an unsteady gait. In adult cattle, fever, anorexia, weakness, excessive salivation, fetid diarrhea, abortion and decreased milk production may be seen. In some cases, abortion can be the only sign of infection in these two species. Similar but milder infections occur in goats. Adult camels do not develop symptoms other than abortion but young animals may have more severe disease.

Communicability

Infections are typically transmitted by mosquitoes and not by direct contact; however, during parturition, necropsy or slaughter, viruses in the tissues can be spread by aerosols and enter the skin through abrasions. The Rift Valley fever virus has also been found in raw milk and may be present in semen.

Diagnostic Tests

Rift Valley fever can be diagnosed by virus isolation. The virus can be isolated from the blood of febrile animals. It can also be recovered from the tissues from dead animals and aborted fetuses; the liver, spleen and brain are generally used. Virus can be grown in numerous cell lines including baby hamster kidney cells, monkey kidney (Vero) cells, chicken embryo reticulum and primary cultures from cattle or sheep. Hamsters, adult or suckling mice, embryonated chicken eggs or 2-day-old lambs can also be used.

Virus titers in tissues are often high; a rapid diagnosis can sometimes be made with complement fixation, neutralization and agar gel diffusion tests on tissue suspensions. Rapid tests may need to be confirmed by virus isolation. Virus antigens can also be detected by immunofluorescent staining of the liver, spleen or brain. Enzyme

immunoassays and immunodiffusion tests can identify virus in the blood.

Serologic tests are helpful in epidemiologic studies but may be of limited use in diagnosis. Available tests include virus neutralization, enzyme-linked immunosorbent assay (ELISA), hemagglutination inhibition, immunofluorescence, complement fixation and immunodiffusion assays. Cross-reactions may occur with other phleboviruses.

Treatment and Vaccination

The only treatment is supportive care. Vaccines are available in some countries.

Morbidity and Mortality

Epidemics of Rift Valley fever tend to occur at intervals, when heavy rainfalls cause infected mosquitoes to hatch and a susceptible animal population has developed. Outbreaks are characterized by large numbers of abortions and high mortality in neonates. Indigenous cattle may have asymptomatic infections, while more severe disease is seen in exotic species.

The mortality rate can be very high in young animals, with fatalities decreasing in older age groups. Deaths are common in neonatal lambs, calves, kids, puppies and kittens. The mortality rate is 90 to 100% in newborn lambs, 40 to 60% in weaners and 15 to 30% in adult sheep. Ewes that abort are more likely to have a fatal infection. In calves, mortality rates range from 10 to 70%. Fewer than 10% of infections in adult cattle are fatal. Abortion rates range from 5 to almost 100% in ewes but are usually less than 10% in cattle.

Post-Mortem Lesions

The most consistent lesion is hepatic necrosis; the necrosis is more extensive and severe in younger animals. In aborted fetuses and newborn lambs, the liver may be very large, yellowish-brown to dark reddish-brown, soft and friable, with patchy congestion. Multiple gray to white necrotic foci are usually present, but may only be visible microscopically. The liver lesions are usually less severe in adult animals and may consist of numerous pinpoint necrotic foci.

Additional lesions may include jaundice, widespread cutaneous hemorrhages and fluid in the body cavities. The peripheral lymph nodes and spleen may be enlarged and edematous and often contain petechiae. The walls of the gallbladder are often edematous, with visible hemorrhages. A variable degree of inflammation or hemorrhagic enteritis can sometimes be found in the intestines. In lambs, many small hemorrhages are usually seen in the abomasal mucosa and the small intestine and abomasum may contain dark chocolate-brown contents, with partially digested blood. In addition, petechial and ecchymotic hemorrhages may be seen on the surface of other internal organs.

Internet Resources

Animal Health Australia.

The National Animal Health Information System (NAHIS)

http://www.brs.gov.au/usr-bin/aphb/ahsq?dislist=alpha

CDC Rift Valley fever page

http://www.cdc.gov/ncidod/dvrd/spb/mnpages/dispages/rvf.htm

Manual for the Recognition of Exotic Diseases of Livestock

http://panis.spc.int/

Medical Microbiology

http://www.gsbs.utmb.edu/microbook

Office International des Epizooties (OIE)

Manual of Standards for Diagnostic Tests and Vaccines

http://www.oie.int/eng/normes/mmanual/a_summry.htm

The Merck Veterinary Manual

http://www.merckvetmanual.com/mvm/index.jsp

WHO Fact Sheet on Rift Valley fever

http://www.who.int/inf-fs/en/fact207.html

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Swine Vesicular Disease

Last Updated: Dec. 10, 2003

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Importance

Swine vesicular disease (SVD) has almost identical clinical signs to foot–and–mouth disease, but is only seen in pigs. Neither disease is present in North America. Differentiation of these two vesicular diseases is important, as the introduction of foot–and–mouth disease could cause severe economic losses.

Etiology

Swine vesicular disease virus (SVDV) is a porcine enterovirus in the family Picornaviridae. It is antigenically related to the human enterovirus Coxsackie B–5 and unrelated to other known porcine enteroviruses.

Species affected

Pigs are the only species that are naturally infected. Humans have been infected while working in a laboratory setting. Baby mice can be experimentally infected.

Geographic distribution

While SVD has been seen in Italy, England, Scotland, Wales, Malta, Austria, Belgium, France, the Netherlands, Germany, Poland, Switzerland, Greece, and Spain, the disease has been eradicated from all European countries. SVD still remains in many countries in the Far East.

Transmission

Transmission can occur by ingestion of contaminated meat scraps and contact with infected animals or infected feces. Pigs can excrete the virus from the nose, mouth, and feces up to 48 hours before clinical signs are seen. Virus can be shed in the feces for up to 3 months following infection.

SVDV can survive for long periods of time in the environment. This virus is resistant to heat up to 157°F (69°C) and pH ranging from 2.5–12. It can also survive up to 2 years in lymphoid tissue contained in dried, salted, or smoked meat.

Incubation period

The incubation period is 2–7 days following exposure to infected pigs and 2–3 days after the ingestion of contaminated feed.

Clinical signs

The clinical signs of swine vesicular disease are very similar to foot–and–mouth disease, and include fever, salivation, and lameness. Vesicles and erosions can be seen on the snout, mammary glands, coronary band, and interdigital areas. Vesicles in the oral cavity are relatively rare. The infection may be subclinical, mild, or severe depending on the virulence of the strain. Severe signs are generally seen only in pigs housed on damp concrete. Younger animals can be more severely affected. Neurological signs due to encephalitis are rare. These include shivering, unsteady gait, and chorea (rhythmic jerking) of the legs. Abortion is not typically seen. Recovery occurs within 2–3 weeks with little permanent damage.

Post mortem lesions

The only post–mortem lesions are the vesicles that can be seen in live pigs. These lesions are similar to those of other vesicular diseases, including foot–and–mouth disease.

Morbidity and Mortality

Swine vesicular disease is considered to be moderately contagious. Compared to foot–and–mouth disease, morbidity is lower and the lesions are less severe. Mortality is not generally a concern with swine vesicular disease.

Diagnosis

Clinical

Swine vesicular disease or other vesicular diseases should be suspected when vesicles or erosions are found on the mouth and/or feet of pigs. In swine vesicular dis-

ease outbreaks, pigs will be the only species affected, the lesions will be mild, and there will be no mortality. Other vesicular diseases must be ruled out with laboratory tests.

Differential diagnosis

Differentials for swine vesicular disease include foot–and–mouth disease, vesicular stomatitis, vesicular exanthema of swine, and chemical or thermal burns.

Laboratory tests

SVDV can be identified using enzyme–linked immunosorbent assay (ELISA), the direct complement fixation test, and virus isolation in pig–derived cell cultures. Virus neutralization and ELISA can be used for serological diagnosis.

Samples to collect

Before collecting or sending any samples from vesicular disease suspects, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent spread of the disease. Since vesicular diseases can not be distinguished clinically, and some are zoonotic, samples should be collected and handled with all appropriate precautions. Samples include vesicular fluid, the epithelium covering vesicles, esophageal–pharyngeal fluid, unclotted whole blood collected from febrile animals, and fecal and serum samples from infected and non–infected animals.

Recommended actions if swine vesicular disease is suspected

Notification of authorities

State and federal veterinarians should be immediately informed of any suspected vesicular disease. Federal: Area Veterinarians in Charge (AVICS) http://www.aphis.usda.gov/vs/area_offices.htm

State vets: http://www.aphis.usda.gov/vs/sregs/official.html

Quarantine and Disinfection

Infected farms or areas should be quarantined. Infected pigs and those in contact with them should be slaughtered and disposed of. The premises should be thoroughly cleaned and disinfected. In the presence of organic matter, sodium hydroxide (1% combined with detergent) can be used. Oxidizing agents and iodophors used with detergents work well for personal disinfection in the absence of gross organic matter.

Public health

Seroconversion and mild clinical disease with one case of meningitis has been seen in laboratory workers.

For More Information

World Organization for Animal Health (OIE)

http://www.oie.int

OIE Manual of Standards

http://www.oie.int/eng/normes/mmanual/a_summry.htm

OIE International Animal Health Code

http://www.oie.int/eng/normes/mcode/A_summry.htm

USAHA Foreign Animal Diseases book

http://www.vet.uga.edu/vpp/gray_book/FAD/

Manual for the Recognition of Exotic Diseases of Livestock

http://www.spc.int/rahs/

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Vesicular Stomatitis

Last Updated: May 20, 2004

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Importance

Vesicular stomatitis is an important zoonotic vesicular disease found in the Americas. This disease has almost identical clinical signs to foot–and–mouth disease in cattle and pigs. The signs of vesicular stomatitis are also very similar to swine vesicular disease and vesicular exanthema of swine. Differentiation of these vesicular diseases is important. The spread of vesicular stomatitis within the United States could bring restrictions on exports of animals and their products to other countries that do not have the disease.

Etiology

Vesicular stomatitis virus (VSV) is a Vesiculovirus in the family Rhabdoviridae. It is a large bullet-shaped RNA virus. There are two strains of VSV that are considered domestic to the United States: New Jersey and Indiana-1; and there are three other exotic strains in South America: Indiana-2 (Cocal), Indiana-3 (Alagoas) and Piry.

Species affected

Horses, donkeys, mules, cattle, swine, South American camelids, and humans can be affected by VSV. Sheep and goats are resistant and rarely show clinical signs. Experimentally, a wide host range has been found including deer, raccoons, bobcats, and monkeys.

Geographic distribution

Vesicular stomatitis occurs only in some areas in the United States, Mexico, Central America and the northern part of South America.

Transmission

Vesicular stomatitis can be transmitted by insect vectors, especially sand flies (*Lutzomyia shannoni*) and black flies (*Simuliidae*), which have both been shown to have transovarial transmission. It can also be transmitted by contact with infected animals and contaminated objects. Humans may be infected by contact or aerosol.

Incubation period

The incubation period of VSV is usually 3–5 days. Vesicles can occur within 24 hours. The incubation period in humans is 24–48 hours.

Clinical signs

All animal species develop fever. Horses are affected the most severely, with oral and coronary band vesicles leading to signs of drooling, chomping, mouth rubbing, and lameness. The signs in cattle and pigs are very similar to foot–and–mouth disease, with vesicles in the oral cavity, mammary glands, coronary band, and interdigital region. Compared to other vesicular diseases, animals with vesicular stomatitis are more likely to have lesions isolated to only one part of the body, such as the mouth or the feet. Animals recover within two weeks, longer with secondary infection.

Post mortem lesions

Mouth and foot vesicles are seen on post mortem. Heart and rumen lesions seen with foot and mouth disease are not seen with vesicular stomatitis.

Morbidity and Mortality

Morbidity varies with conditions, but can be up to 90%. Infection is typically sporadic in an exposed group. Death is not as common in young animals as with foot and mouth disease. The mortality rate is low.

Diagnosis

Clinical

Diagnosis is similar to that of foot and mouth disease due to the similar clinical signs. Vesicular stomatitis affects horses, but foot and mouth disease does not. In addition, vesicular stomatitis is not as contagious and does not spread as rapidly

through a group of animals. Most VSV-infected animals have lesions in only one area of the body. Heart and rumen lesions typical for foot and mouth disease are not seen in vesicular stomatitis. Animals kept in stables during a vesicular stomatitis outbreak are less likely to contract the disease.

Differential diagnosis

In cattle, differentials include foot and mouth disease, foot rot, and chemical or thermal burns. Oral lesions can be similar to those seen with rinderpest, infectious bovine rhinopneumonitis, bovine virus diarrhea, malignant catarrhal fever, and bluetongue. In pigs, differentials include foot and mouth disease, swine vesicular disease, vesicular exanthema of swine, foot rot, and chemical and thermal burns.

Laboratory tests

VSV can be isolated in tissue culture, or detected by RT-PCR. Viral antigen can be detected using ELISA, complement fixation, or virus neutralization tests. Paired acute and convalescent serum samples may be tested for antibodies using ELISA, virus neutralization, or complement fixation tests.

Samples to collect

Before collecting or sending any samples from vesicular disease suspects, the proper authorities should be contacted. Samples should only be sent under secure conditions and to authorized laboratories to prevent spread of the disease. Since vesicular diseases can not be distinguished clinically, and some are zoonotic, samples should be collected and handled with all appropriate precautions. Samples include vesicular fluid, the epithelium covering vesicles, esophageal–pharyngeal fluid, unclotted whole blood collected from febrile animals, and fecal and serum samples from infected and non-infected animals.

Recommended actions if vesicular stomatitis is suspected

Notification of authorities

State and federal veterinarians should be immediately informed of any suspected vesicular disease. Federal: Area Veterinarians in Charge (AVIC): http://www.aphis.usda.gov/vs/area_offices.htm

State vets: http://www.aphis.usda.gov/vs/sregs/official.html

Quarantine and Disinfection

Isolation of animals showing clinical signs helps control the spread of vesicular stomatitis within a herd. There should be no movement of animals from an infected property for at least 30 days after all lesions are healed. Insect control may help prevent disease spread. Disinfectants include 2% sodium carbonate, 4% sodium hydroxide, 2% iodophore disinfectants, and chlorine dioxide.

Public health

Vesicular stomatitis occurs often in humans as an influenza-like illness rarely causing vesicles. Infected humans develop fever, headache, muscular aches, and, rarely, oral blisters similar to herpes virus. Recovery usually occurs within 4–7 days.

For More Information

World Organization for Animal Health (OIE)

http://www.oie.int

OIE Manual of Standards

http://www.oie.int/eng/normes/mmanual/a_summry.htm

OIE International Animal Health Code

http://www.oie.int/eng/normes/mcode/A_summry.htm

USAHA Foreign Animal Diseases book

http://www.vet.uga.edu/vpp/gray_book/FAD/

References

Mebus, C.A. "Vesicular stomatitis." In *Foreign Animal Diseases*. Richmond, VA: United States Animal Health Association, 1998, pp. 419–423.

"Vesicular stomatitis." In *Manual of Standards for Diagnostic Tests and Vaccines*. Paris: World Organization for Animal Health, 2000, pp. 93–99.